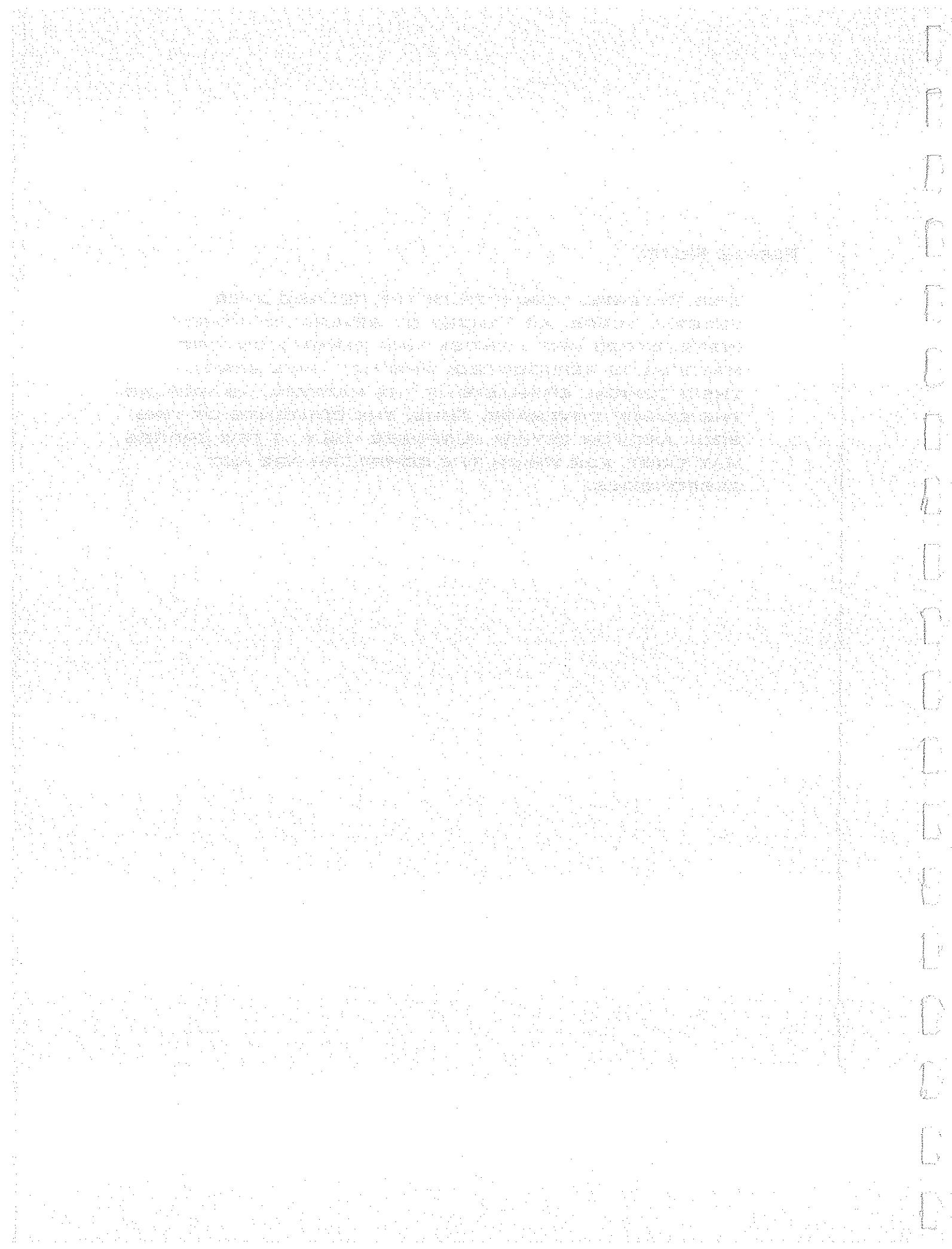


PLEASE NOTE:

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SEVERAL YEARS, AS TAUGHT BY SEVERAL DIFFERENT
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THEIR TOPICAL EMPHASIS OF THE MATERIAL AS WELL AS
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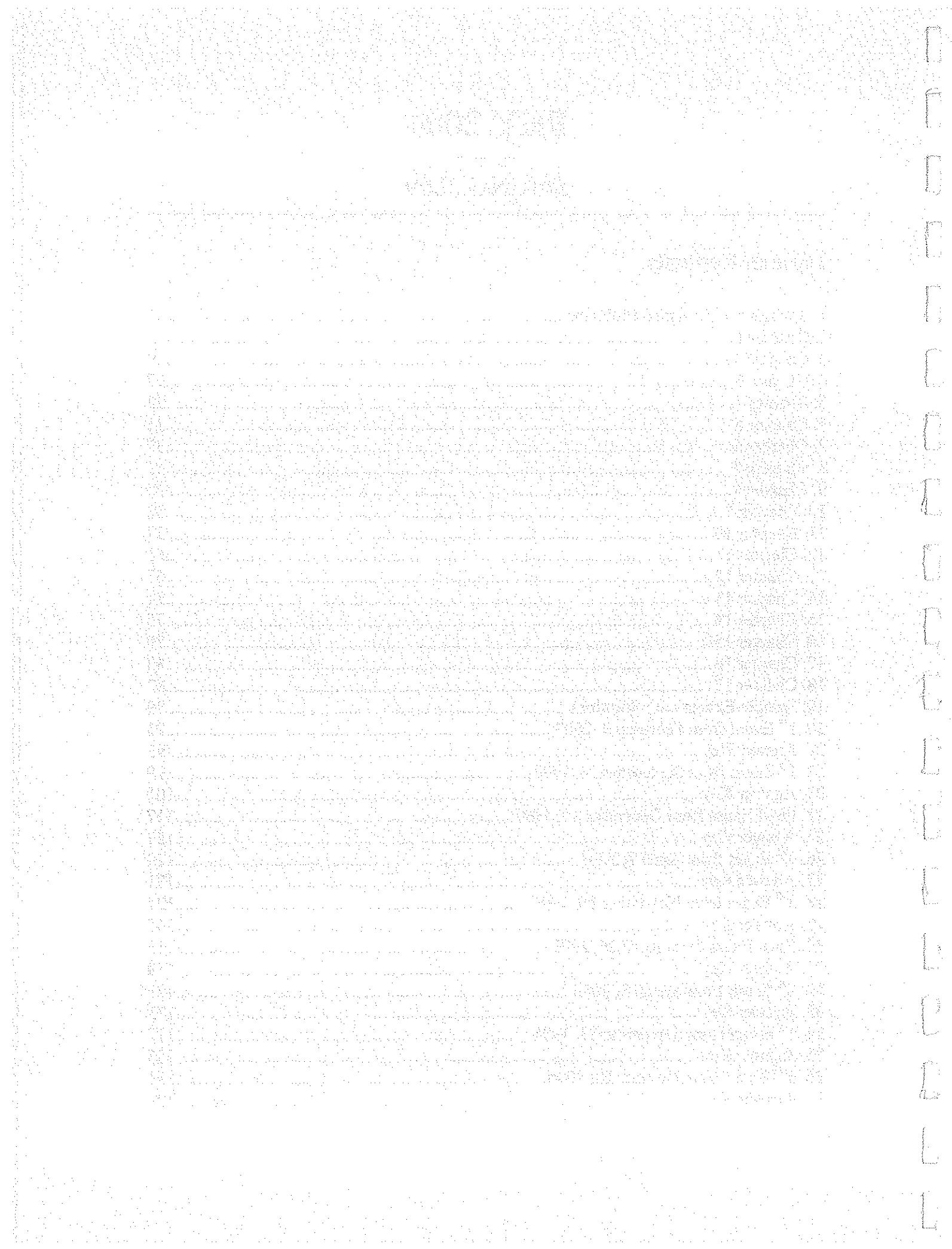


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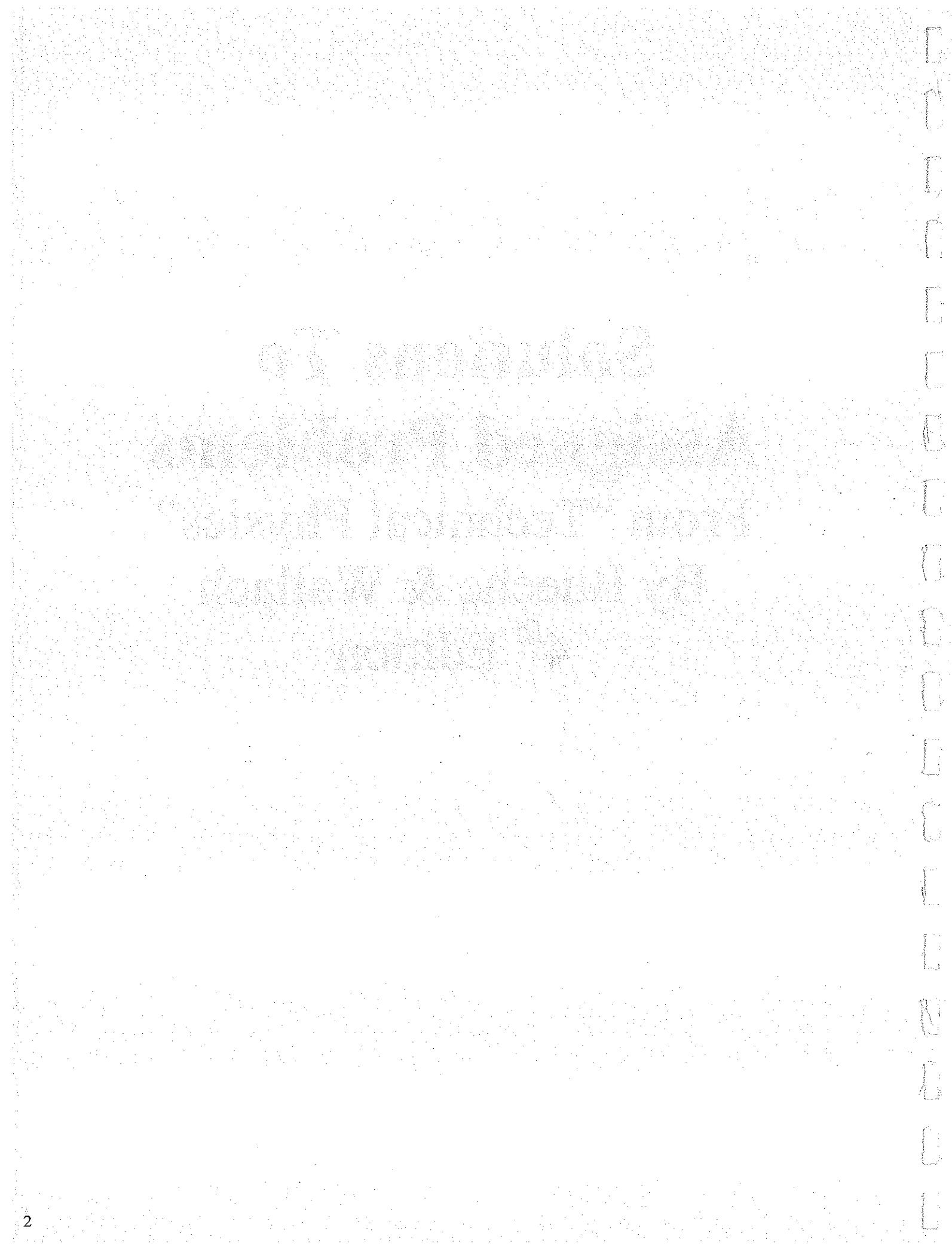
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Solutions To Assigned Problems

From "Technical Physics"
By Bueche & Wallach
4th Edition



PHY 2004 - SOLUTIONS TO ASSIGNED PROBLEMS

Problems from "Technical Physics" by Bueche & Walloch, 4th ed.

Chapter 1 (3, 11, 17, 22, 23, 31, 34, 35, 37, 39, 43, 44, 47)

1-3) Method: Lay vectors tail-to-head.

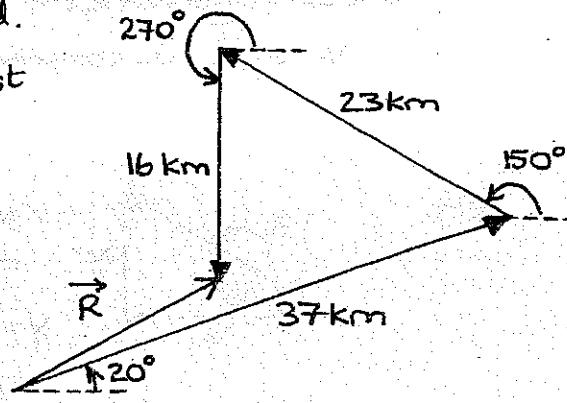
Resultant \vec{R} connects tail of first vector to head of last vector.

Here, scale is $1 \text{ cm} = 10 \text{ km}$.

Measurement on drawing gives

$$|\vec{R}| = 17 \text{ km}$$

$$\text{angle} = 30^\circ \text{ (rel. to x-axis)}$$



1-11) Since triangle is a right triangle, we can use the Pythagorean formula to find the length of side C.

$$(a) C = \sqrt{A^2 + B^2} = 2^2 + 3^2 \text{ m} = 3.6 \text{ m} \text{ (to 2 sig. fig.)}$$

$$(b) \sin \theta = A/C = 2/3.6 = 0.56$$

$$(c) \cos \theta = B/C = 3/3.6 = 0.83$$

$$(d) \tan \theta = A/B = 2/3 = 0.67$$

1-17) Note that since we know angle ϕ (not θ), side A becomes the adjacent side and side B the opposite.

$$(a) \sin \phi = B/C \Rightarrow C = B/\sin \phi = 3 \text{ m} / \sin 50^\circ = 3.9 \text{ m} \text{ (to 2 sig. fig.)}$$

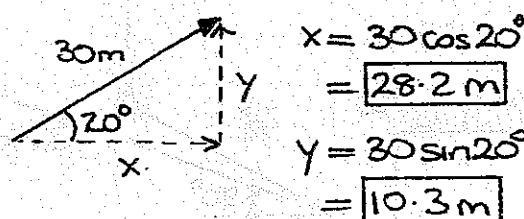
$$(b) \tan \phi = B/A \Rightarrow A = B/\tan \phi = 3 \text{ m} / \tan 50^\circ = 2.5 \text{ m}$$

1-22) Either of two methods can be applied to this problem:

Method I (safer)

- Draw a rough diagram
- Identify a right triangle
- Use trigonometry to find x- and y-components

(a)



- Identify $\theta =$ angle of vector measured CCW rel. to x-axis
- x-component = length $\times \cos \theta$
- y-component = length $\times \sin \theta$

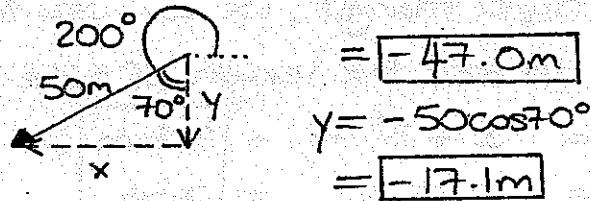
$$x = 30 \cos 20^\circ$$

$$= 28.2 \text{ m}$$

$$y = 30 \sin 20^\circ$$

$$= 10.3 \text{ m}$$

(b)



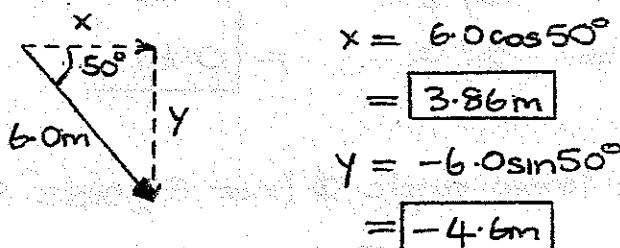
$$x = 50 \cos 200^\circ$$

$$= -47.0 \text{ m}$$

$$y = 50 \sin 200^\circ$$

$$= -17.1 \text{ m}$$

(c)



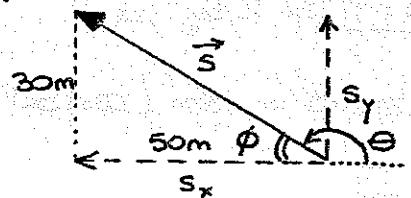
$$x = 6.0 \cos(-50^\circ)$$

$$= 3.86 \text{ m}$$

$$y = 6.0 \sin(-50^\circ)$$

$$= -4.6 \text{ m}$$

1-23)



$$\tan \phi = \frac{30}{50} \Rightarrow \phi = 31.0^\circ$$

$$\text{magnitude, } |\vec{s}| = \sqrt{s_x^2 + s_y^2}$$

$$= \sqrt{(-50)^2 + (30)^2} \text{ m}$$

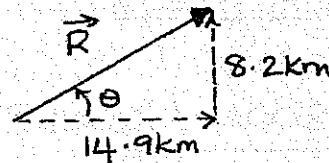
$$= 58.3 \text{ m}$$

$$\text{angle, } \theta = 180^\circ - \phi$$

$$= 149^\circ$$

1-31) Method : Resolve each vector into components. Add x- and y-components separately. Combine to obtain resultant vector.

vector	x	y	Recall (see 1-22)
37 at 20°	34.8	12.7	$x = \text{length} \times \cos \theta$
23 at 150°	-19.9	11.5	$y = \text{length} \times \sin \theta$
16 at 270°	0.0	-16.0	
resultant, \vec{R}	14.9	8.2	



$$\text{magnitude}, |\vec{R}| = \sqrt{14.9^2 + 8.2^2} \text{ km}$$

$$= 17.0 \text{ km}$$

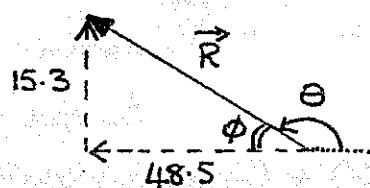
$$\text{angle}, \theta = \text{inv tan} \left(\frac{8.2}{14.9} \right)$$

$$= 28.8^\circ$$

1-34) Apply same method as in 1-31.

vector	x	y
6 at 90°	0.0	6.0
20 at 180°	-20.0	0.0
30 at 162°	-28.5	9.3
resultant	-48.5	15.3

Note: resultant is vector from first office to second.



$$\text{magnitude}, |\vec{R}| = \sqrt{48.5^2 + 15.3^2} \text{ paces}$$

$$= 50.9 \text{ paces}$$

$$\text{angle}, \theta = 180^\circ - \phi$$

$$= 162.5^\circ$$

$$\tan \phi = \frac{15.3}{48.5} \Rightarrow \phi = 17.5^\circ$$

Finally, distance between offices = $|\vec{R}| = 50.9 \text{ paces}$

Angle of vector from second office to first

$$= \theta + 180^\circ = 342.5^\circ$$

1-35) Resultant has x component = $-5 + 0 + 20 \text{ N} = 15 \text{ N}$.
 " y component = $-7 + 30 - 16 \text{ N} = 7 \text{ N}$.
 " magnitude = $\sqrt{15^2 + 7^2} \text{ N} = 16.6 \text{ N}$.
 " makes angle to x axis = $\text{inv tan}\left(\frac{7}{15}\right) = 25.0^\circ$.

1-37) We must resolve the velocity into horizontal and vertical components, v_{\parallel} and v_{\perp} :

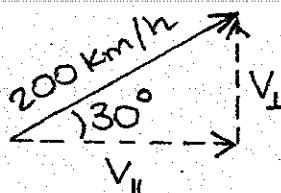
(a) Plane rises at speed $v_1 = (200 \text{ km/h}) \sin 30^\circ$

$$= 100 \text{ km/h}.$$

(b) Plane moves over ground at speed

$$V_{||} = (200 \text{ km/h}) \cos 30^\circ$$

$$= 173 \text{ km/h.}$$



1-39) We perform arithmetic operations to "x" and "y" components separately:

$$\begin{aligned} \vec{A} = (10, 0) \text{ m} \\ \vec{B} = (15, 0) \text{ m} \end{aligned} \quad \left. \begin{array}{l} \vec{A} + \vec{B} = (25, 0) \text{ m or } 25 \text{ m due east.} \\ \vec{A} - \vec{B} = (-5, 0) \text{ m or } 5 \text{ m due west.} \end{array} \right\} \Rightarrow$$

$x = \text{east}$ $y = \text{north}$

$$2\vec{A} - \vec{B} = (5, 0) \text{ m or } 5 \text{ m due east.}$$

1-43) Let $\vec{v}_{\text{plane/ground}}$ mean "velocity of plane relative to ground".

$$\text{Then } \vec{V}_{\text{plane/grand}} = \vec{V}_{\text{plane/air}} + \vec{V}_{\text{air/grand}}$$

↑ due to engines ↑ due to wind

$$= (400, 0) + (-80, 0) \text{ km/h}$$

$$= (320, 0) \text{ km/h or } 320 \text{ km/h due east.}$$

Note: When add relative velocities as above, subscripts multiply like fractions - e.g.,

$$\text{plane/ground} = \text{plane/air} \times \text{air/ground}$$

1-44) Apply same method as in 1-43.

$$\begin{aligned}\vec{v}_{\text{bug/grand}} &= \vec{v}_{\text{bug/board}} + \vec{v}_{\text{board/grand}} \\ (\text{i.e., } v_{\text{bug/grand}} &= v_{\text{bug/board}} \times v_{\text{board/grand}}) \\ \vec{v}_{\text{bug/grand}} &= (3.0, -6.0) \text{ cm/s} + (15.0, 0) \text{ cm/s} \\ &= \boxed{(18.0, -6.0) \text{ cm/s}}\end{aligned}$$

1-47) (a) 0.000579

$$= 5.79 \times 10^{-4}$$

(b) 0.0036

$$= 3.6 \times 10^{-3}$$

(c) 7490

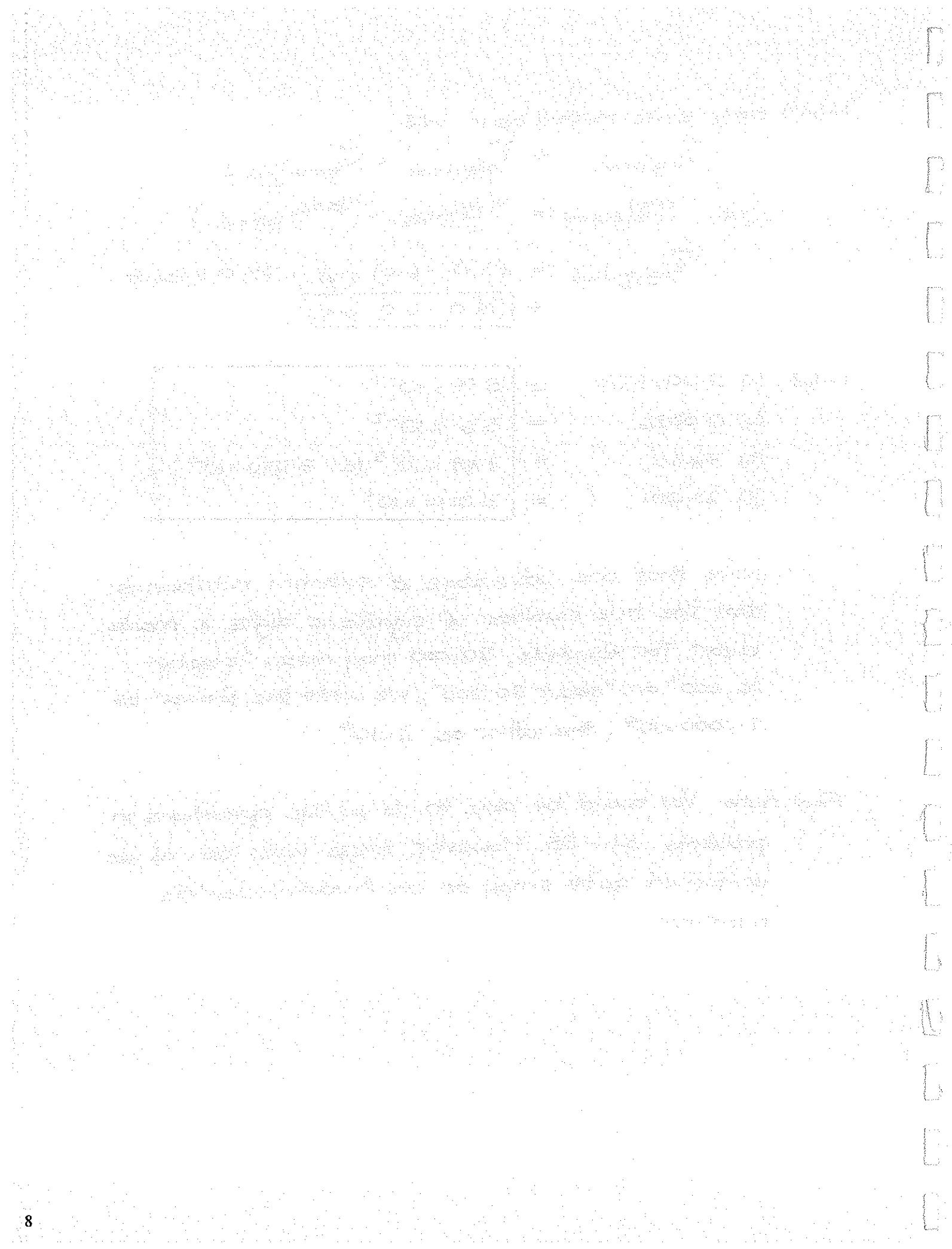
$$= 7.49 \times 10^{-3} \text{ (or } 7.490 \times 10^{-3})$$

(d) 20,001

$$= 2.0001 \times 10^4$$

Note that one advantage of scientific notation is that the true number of significant digits is made clear. For example, 20,000 may mean "exactly 20,000" or "about 20,000"; we write the former as 2.0000×10^4 , the latter as 2×10^4 .

Final note: You should be able to do all the operations in problems 46-55. However, these tasks can all be performed quite simply on any (modern) scientific calculator.



Chapter 2 (5, 7, 17, 23, 27, 30, 31, 32, 35, 37, 44, 50, 52, 53, 54)

$$2-5) \text{ average speed} = \frac{\text{distance}}{\text{time}} = \frac{500 \text{ miles}}{3 \text{ hours } 13 \text{ mins}} \\ = \frac{500 \text{ miles}}{3 \frac{13}{60} \text{ hours}} = \boxed{155 \text{ miles/hour}}$$

but

$$\text{average velocity} = \frac{\text{vector displacement}}{\text{time}} = \boxed{0 \text{ miles/hour}}$$

(since start and finish are at same place).

$$2-7) 10 \text{ miles} = 10 \text{ miles} \times \left(\frac{5280 \text{ ft}}{1 \text{ mile}} \right) \times \left(\frac{12 \text{ in}}{1 \text{ ft}} \right) \times \left(\frac{2.54 \text{ cm}}{1 \text{ in}} \right) \\ = 10 \times 5280 \times 12 \times 2.54 \text{ cm} \\ = \boxed{1.61 \times 10^6 \text{ cm}}$$

Note that we apply the usual rules of algebra to cancel units that appear in both the top and bottom of fractions.

2-17) (a) To find average speed, we need the total distance.

The object moves from $x = 2 \text{ m}$ to $x = 10 \text{ m}$ (a distance of 8 m), then from $x = 10 \text{ m}$ to $x = 0 \text{ m}$ (a distance of 10 m).

$$\Rightarrow \text{average speed} = \frac{\text{total distance}}{\text{total time}} = \frac{18 \text{ m}}{10 \text{ s}} = \boxed{1.8 \text{ m/s.}}$$

(b) The average velocity depends on the net displacement,

$$x_f - x_i = 0 \text{ m} - 2 \text{ m} = -2 \text{ m.}$$

$$\Rightarrow \text{average velocity} = \frac{\text{net displacement}}{\text{total time}} = \frac{-2 \text{ m}}{10 \text{ s}} = \boxed{-0.2 \text{ m/s.}}$$

2-23) By definition, average acceleration $\vec{a} = \frac{\vec{v}_f - \vec{v}_i}{t}$.

We don't know the direction, but $|\vec{v}_f - \vec{v}_i| = 20 \text{ m/s.}$

$$\Rightarrow \text{magnitude of avg. acceleration, } |\vec{a}| = \frac{20 \text{ m/s}}{8 \text{ s}} = \boxed{2.5 \text{ m/s}^2}$$

2-27) The minimum stopping time is obtained by braking as hard as possible, i.e., by achieving the maximum possible deceleration.

$$V_f = V_i + at \Rightarrow t = \frac{V_f - V_i}{a} = \frac{0 - 20 \text{ m/s}}{(-6 \text{ m/s}^2)} = 3.3 \text{ s}$$

(Note that a deceleration of 6 m/s^2 is an acceleration of -6 m/s^2 .)

2-30) We are given $V_i = 500 \text{ m/s}$, $V_f = 0 \text{ m/s}$, $x = 0.170 \text{ m}$.

$$\text{Use } V_f^2 = V_i^2 + 2ax \Rightarrow a = \frac{V_f^2 - V_i^2}{2x} = \frac{0^2 - 500^2 \text{ m}^2/\text{s}^2}{2 \times 0.170 \text{ m}} = -7.35 \times 10^5 \text{ m/s}^2.$$

$$\text{Use } V_f = V_i + at \Rightarrow t = \frac{V_f - V_i}{a} = \frac{0 - 500 \text{ m/s}}{-7.35 \times 10^5 \text{ m/s}^2} = 6.8 \times 10^{-4} \text{ s.}$$

(Strictly, the deceleration equals $-a$, or $+7.35 \times 10^5 \text{ m/s}^2$.)

2-31) We are given $V_i = 6.0 \text{ m/s}$, $x = 100 \text{ m}$, $t = 10.0 \text{ s}$, $a = \text{constant}$.

$$\text{Use } x = V_i t + \frac{1}{2} a t^2 \Rightarrow a = \frac{2}{t^2} (x - V_i t) \\ = \frac{2}{(10.0 \text{ s})^2} \times (100 \text{ m} - 6.0 \text{ m/s} \times 10.0 \text{ s}) \\ = 0.8 \text{ m/s}^2.$$

$$\text{Use } V_f = V_i + at \Rightarrow V_f = 6.0 \text{ m/s} + 0.8 \text{ m/s}^2 \times 10.0 \text{ s} \\ = 14 \text{ m/s.}$$

$$2-32)(a) \text{ avg. acceleration between A and B} = \frac{V_B - V_A}{t_B - t_A} = \frac{4 - 0 \text{ m/s}}{30 - 0 \text{ s}} \\ = 0.133 \text{ m/s}^2.$$

$$(b) \text{ avg. acceleration between C and D} = \frac{V_D - V_C}{t_D - t_C} = \frac{6 - 6 \text{ m/s}}{70 - 45 \text{ s}} \\ = 0 \text{ m/s}^2.$$

(c) For interval AB we know $v_i = v_A = 0$, $v_f = v_B = 4 \text{ m/s}$,
 $t = t_B - t_A = 30 \text{ s}$ and $a = 0.133 \text{ m/s}^2$.

$$\Rightarrow \text{distance travelled}, \quad x = v_i t + \frac{1}{2} a t^2$$

$$= 0 \text{ m/s} \times 30 \text{ s} + \frac{1}{2} \times 0.133 \text{ m/s}^2 \times (30 \text{ s})^2$$

$$= \boxed{60 \text{ m.}}$$

(d) For interval CD we know $v_i = v_c = v_f = v_D = 6 \text{ m/s}$,

$$t = t_D - t_c = 25 \text{ s} \text{ and } a = 0 \text{ m/s}^2$$

$$\Rightarrow \text{distance travelled}, \quad x = v_i t + \frac{1}{2} a t^2$$

$$= 6 \text{ m/s} \times 25 \text{ s} + \frac{1}{2} \times 0 \text{ m/s}^2 \times (25 \text{ s})^2$$

$$= \boxed{150 \text{ m.}}$$

2-35) Hint: We have two separate objects moving with constant accelerations. What property of the two objects must be the same when the police officer catches the car?

Method: Write separate equations for the displacement of each vehicle from the corner as a function of time.

The police officer catches the car at the time t when $x_{\text{police}}(t) = x_{\text{car}}(t)$.

car: Has constant velocity $v = 90 \frac{\text{km}}{\text{hr}} \times \left(\frac{1000 \text{ m}}{1 \text{ km}}\right) \times \left(\frac{1 \text{ hr}}{3600 \text{ s}}\right)$

$$= 25 \text{ m/s.}$$

$$\Rightarrow x_{\text{car}}(t) = vt$$

$$= 25t$$

where t is measured in seconds from the moment the car passes the corner.

police cruiser: until $t=5s$ has velocity $v_i = 0$; after that has constant acceleration $a = 5 \text{ m/s}^2$.

$$x_{\text{police}}(t) = v_i t + \frac{1}{2} a(t-5)^2 = 2.5(t-5)^2.$$

[Here $(t-5)$ appears instead of t since acceleration does not start until $t=5s$.]

Police cruiser catches car when

$$\begin{aligned} x_{\text{police}}(t) &= x_{\text{car}}(t) \\ 2.5(t-5)^2 &= 25t \\ 2.5t^2 - 25t + 62.5 &= 25t \\ 2.5t^2 - 50t + 62.5 &= 0. \end{aligned}$$

This is a quadratic equation, which has two solutions for t (see Busche, p. 652)

$$\begin{aligned} t &= \frac{50 \pm \sqrt{50^2 - 4 \times 2.5 \times 62.5}}{2 \times 2.5} \\ &= 1.34s \text{ or } 18.66s. \end{aligned}$$

Although mathematically correct, the solution $t=1.34s$ is physical nonsense – the police officer didn't give chase until $t=5s$.

\Rightarrow The cruiser catches the car at time $t=18.66s$.

To find the distance from the corner, substitute $t=18.66s$ into either $x_{\text{car}}(t)$ or $x_{\text{police}}(t)$:

e.g., $x = 25 \times 18.66 = 467 \text{ m}$

Velocity of cruiser, $v_{\text{police}} = v_i + a(t-5s) = 0 + (5 \text{ m/s}^2)(18.66 - 5) \text{ s}$
 $= 68.3 \text{ m/s}$
 $= 246 \text{ km/h or } 152 \text{ miles/h!}$

2-37) Choose positive-y direction upwards. Then we know

$$v_i = 0 \text{ m/s}, a = -g = -9.8 \text{ m/s}^2, \text{ and } y = -13.0 \text{ m.}$$

$$\text{Using } y = v_i t + \frac{1}{2} a t^2, \quad t = \sqrt{\frac{2y}{a}} = \sqrt{\frac{2 \times (-13.0 \text{ m})}{(-9.8 \text{ m/s}^2)}} \\ = 1.63 \text{ s.}$$

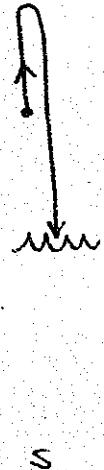
$$\text{Then } v_f = v_i + at = 0 \text{ m/s} + (-9.8 \text{ m/s}^2) \times 1.63 \text{ s} = -16.0 \text{ m/s.}$$

2-44) Choose positive-y direction upwards. Then we know

$$v_i = +25 \text{ m/s}, a = -g = -9.8 \text{ m/s}^2, \text{ and } y = -30 \text{ m.}$$

Using $y = v_i t + \frac{1}{2} a t^2$, have quadratic equation
for t : $\frac{1}{2} a t^2 + v_i t - y = 0$

$$\Rightarrow t = \frac{-v_i \pm \sqrt{v_i^2 - 4 \times \frac{1}{2} a \times (-y)}}{2 \times \frac{1}{2} a} \\ = \frac{-25 \pm \sqrt{25^2 - 4 \times \frac{1}{2} (-9.8) \times 30}}{2 \times \frac{1}{2} (-9.8)} \text{ s} \\ = -1.0 \text{ s or } +6.1 \text{ s.}$$



Just as in 2-35, we have a mathematically correct, but physically nonsensical solution, $t = -1.0 \text{ s}$, which we discard.

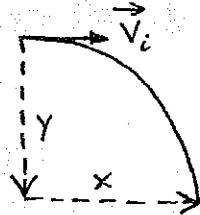
\Rightarrow The ball reaches the water after time $t = 6.1 \text{ s.}$

$$\text{Now use } v_f^2 = v_i^2 + 2ay = (25 \text{ m/s})^2 + 2 \times (-9.8 \text{ m/s}^2) \times (-30 \text{ m}) \\ = 1213 (\text{m/s})^2$$

$$\text{Velocity just before hits, } v_f = -34.8 \text{ m/s.}$$

2-50) Hint: In problems involving projectile motion, we can write separate equations for the motion in the x- and y-directions, connected only by the time t appearing in each equation.

Method: Use y-equation to find time ball is in air. Then use time and distance travelled horizontally to deduce initial velocity of ball.



Vertical direction: since ball is launched horizontally, we know $V_{iy} = 0 \text{ m/s}$; also $a_y = -g = -9.8 \text{ m/s}^2$, $y = -30 \text{ m}$.

Using $y = V_{iy}t + \frac{1}{2}a_y t^2$, $t = \frac{-V_{iy} \pm \sqrt{V_{iy}^2 - 4 \times \frac{1}{2}a_y \times (-y)}}{2 \times \frac{1}{2}a_y}$

$$= \frac{0 \pm \sqrt{0^2 - 4 \times \frac{1}{2}(-9.8) \times 30}}{2 \times \frac{1}{2}(-9.8)} \text{ s}$$

$$= \pm 2.47 \text{ s.}$$

Once again, the negative solution is unphysical.

\Rightarrow The ball is in the air for a time $t = 2.47 \text{ s.}$

[Quicker method: since ball starts with zero vertical velocity, time in air is just that for any object to fall through a height $h = 30 \text{ m}$,

$$t = \sqrt{\frac{2h}{g}} = \sqrt{\frac{2 \times 30}{9.8}} \text{ s} = 2.47 \text{ s.}]$$

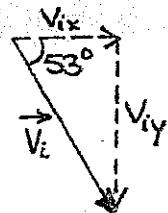
horizontal direction: since $a_x = 0$, $V_{ix} = \frac{x}{t} = \frac{50 \text{ m}}{2.47 \text{ s}} = 20.2 \text{ m/s}$

\Rightarrow initial speed of ball = 20.2 m/s

2-52) Method: Again we treat the x- and y-motion separately. Here, however, the initial velocity has non-zero components in both x- and y-directions:

$$V_{ix} = V_i \cos 53^\circ = 300 \text{ m/s} \times 0.6 = 180 \text{ m/s}$$

$$V_{iy} = -V_i \sin 53^\circ = -300 \text{ m/s} \times 0.8 = -240 \text{ m/s}$$



y-direction: We know $v_{iy} = -240 \text{ m/s}$, $a_y = -g = -9.8 \text{ m/s}^2$, and $y = -2000 \text{ m}$.

$$\text{Using } y = v_{iy}t + \frac{1}{2}at^2, t = \frac{-v_{iy} \pm \sqrt{v_{iy}^2 - 4 \times \frac{1}{2}a_y(-y)}}{2 \times \frac{1}{2}a_y}$$

$$= \frac{240 \pm \sqrt{(240)^2 - 4 \times \frac{1}{2}(-9.8) \times 2000}}{2 \times \frac{1}{2}(-9.8)} \text{ s}$$

$$= -56.2 \text{ s or } 7.3 \text{ s.}$$

As usual, we want the positive solution - the bomb hits the ground after 7.3 s.

x-direction: We know $v_{ix} = 180 \text{ m/s}$, $a_x = 0$, $t = 7.3 \text{ s}$.

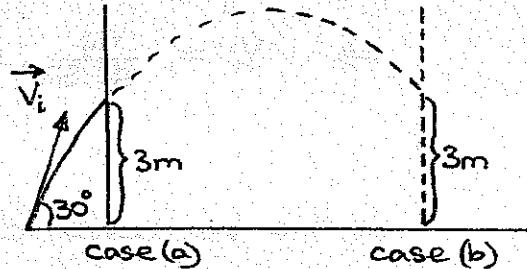
$$\text{Distance travelled horizontally, } x = v_{ix}t + \frac{1}{2}a_x t^2$$

$$= 180 \text{ m/s} \times 7.3 \text{ s}$$

$$= \boxed{1310 \text{ m.}}$$

2-53) Method : Find the time t at which $y = 3 \text{ m}$. There will be two solutions, corresponding to cases (a) and (b).

Use the time and the horizontal velocity to find the distance from the wall.



$$v_{ix} = 20 \text{ m/s} \times \cos 30^\circ = 17.3 \text{ m/s}$$

$$v_{iy} = 20 \text{ m/s} \times \sin 30^\circ = 10.0 \text{ m/s}$$

y-direction: We know $v_{iy} = 10.0 \text{ m/s}$, $a_y = -g = -9.8 \text{ m/s}^2$, $y = 3 \text{ m}$.

$$\text{Using } y = v_{iy}t + \frac{1}{2}a_y t^2, t = \frac{-v_{iy} \pm \sqrt{v_{iy}^2 - 4 \times \frac{1}{2}a_y(-y)}}{2 \times \frac{1}{2}a_y}$$

$$= \frac{-10 \pm \sqrt{10^2 - 4 \times \frac{1}{2}(-9.8) \times (-3)}}{2 \times \frac{1}{2}(-9.8)} \text{ s}$$

$$= 0.37 \text{ or } 1.68 \text{ s.}$$

horizontal direction: distance travelled is $x = v_{ix} t$

Substituting $t = 0.37$ and $1.68s$, find distance from bay to wall is $6.4m$ or $29m$

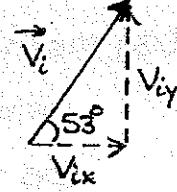
2-54) Method: We can use basically the same method as for the last few problems to relate the time in the air to the vertical component of the initial velocity. However, a quicker method uses the equation

$$v_y = v_{iy} + a_y t \text{ with } a_y = -g = -9.8 \text{ m/s}^2.$$

A total time of $5.0s$ means $2.5s$ going up and $2.5s$ coming down (can you show this?). Therefore, at $t = 2.5s$, $v_{fy} = 0 \text{ m/s}$, so $v_{iy} = gt = 9.8 \text{ m/s}^2 \times 2.5s = 24.5 \text{ m/s}$

Now, $v_{iy} = v_i \sin 53^\circ$

$$\Rightarrow v_i = \frac{v_{iy}}{\sin 53^\circ} = \frac{24.5 \text{ m/s}}{0.8} = 30.7 \text{ m/s}$$



In the horizontal direction we can use

$$x = v_{ix} t$$

$$\text{with } v_{ix} = v_i \cos 53^\circ = 30.7 \text{ m/s} \times 0.6 \\ = 18.5 \text{ m/s}$$

In a total time of $5.0s$, the total distance travelled horizontally is

$$x = 18.5 \text{ m/s} \times 5.0s$$

$$= 92 \text{ m}$$

Chapter 3 (2, 5, 10, 18, 22, 25, 27, 30, 31, 36, 38, 39, 43)

3-2) This problem focuses on the relation between mass, m , and weight, $w = mg$.

- (a) To prevent a stationary object accelerating, it must be supported by a net vertical force equal, and opposite, to its weight.

$$\Rightarrow \text{support force} = mg = 800\text{kg} \times 9.8\text{m/s}^2 \\ = 7840\text{ N.}$$

- (b) If greatest weight that can be supported is $w = 50,000\text{N}$,
 largest mass $= \frac{w}{g} = \frac{50,000\text{N}}{9.8\text{m/s}^2}$
 $= 5,100\text{ kg.}$

3-5) (a) From Newton's second law, $m = \frac{F}{a} = \frac{30\text{N}}{5.0\text{m/s}^2} = 6.0\text{kg.}$

(b) Using the same law, $a' = \frac{F'}{m} = \frac{40\text{N}}{6.0\text{kg}} = 6.67\text{m/s}^2.$

- 3-10) (a) Mass is an invariant quantity which does not change from location to location.

$$\Rightarrow \text{mass of object on Mars} = \text{mass on earth} = 5.0\text{kg.}$$

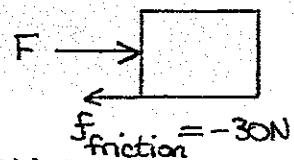
(b) Weight of object on Mars $= mg_{\text{Mars}} = 5.0\text{kg} \times 3.9\text{m/s}^2$
 $= 19.5\text{N}$

3-18) $\sum F_x = ma_x \Rightarrow F + f_{\text{friction}} = ma_x$

$$F = ma_x - f_{\text{friction}}$$

$$= 6.0\text{kg} \times 8.0\text{m/s}^2 + 30\text{N}$$

$$= 78\text{N}$$



NB: only need to worry about horizontal forces

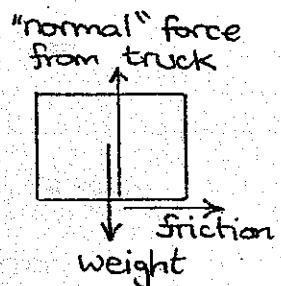
3-22) From the definition in Chapter 2, the average acceleration is $a = \frac{v_f - v_i}{t} = \frac{0 - 25 \text{ m/s}}{0.30 \text{ s}} = -83.3 \text{ m/s}^2$.

⇒ The car's average deceleration is 83.3 m/s^2 .

Applying Newton's 2nd Law, force $F = ma = 40 \text{ kg} \times 83.3 \text{ m/s}^2 = 3300 \text{ N}$.

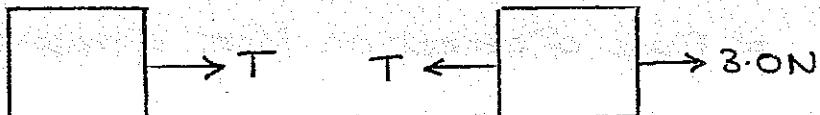
3-25) Consider the box: in order not to slip, it must have the same acceleration as the truck. The only force that can bring about this acceleration is the force of friction. (The other forces acting on the box are vertical.) Thus the maximum acceleration without slipping is related to the maximum frictional force by

$$\Rightarrow a_{\max} = \frac{F_{\max}}{m_{\text{box}}} = \frac{280 \text{ N}}{30 \text{ kg}} = 9.3 \text{ m/s}^2.$$



3-27) Draw separate "free-body" diagrams for the two blocks:

(can ignore vertical forces)



Here T is the tension in the connecting cord.

Applying Newton's 2nd law to each block in turn:

$$\sum F_x = m a_x \Rightarrow T = (0.7 \text{ kg}) a \quad \textcircled{1} \quad (\text{left block})$$

$$3.0 \text{ N} - T = (0.7 \text{ kg}) a \quad \textcircled{2} \quad (\text{right } ")$$

Solve for acceleration, a , and tension, T , using your favorite method for treating simultaneous equations.

For instance, use equation ① to replace T in equation ②, obtaining

$$3.0N - (0.7\text{kg})a = (0.7\text{kg})a$$

$$(1.4\text{kg})a = 3.0N$$

$$a = \frac{3.0N}{1.4\text{kg}} = 2.1 \text{ m/s}^2.$$

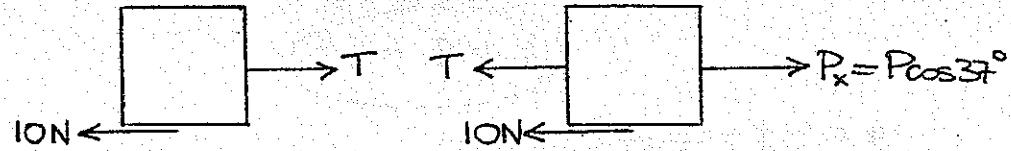
Then, from ①,

$$T = (0.7\text{kg})a$$

$$= 0.7\text{kg} \times 2.1 \text{ m/s}^2 = 1.5 \text{ N}$$

3-30) Again, draw separate free-body diagrams for the two blocks:

(only need horizontal forces)



$$\sum F_x = ma_x \Rightarrow T - 10N = (4.0\text{kg})(0.8\text{m/s}^2) \quad (\text{left})$$

$$\text{tension in connecting cord, } T = 10N + 4.0 \times 0.8 \text{ N}$$

$$= 13.2 \text{ N}$$

$$P_x - T - 10N = (4.0\text{kg})(0.8\text{m/s}^2) \quad (\text{right})$$

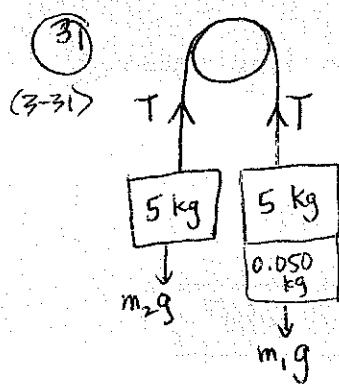
$$P_x = T + 10N + 4.0 \times 0.8 \text{ N}$$

$$= 26.4 \text{ N}$$

$$\text{pulling force, } P = \frac{P_x}{\cos 37^\circ} = 33.1 \text{ N}$$

3-31) Like 3-27 and 3-30, this problem involves coupled motion of two bodies connected by a massless string. Once again, we tackle the problem by writing separate equations for each body. However, the physical arrangement of the objects (see Fig. 3.13) is more complicated than in the previous problems.

Chp 3



$$\text{Let } m_2 = 5 \text{ kg}$$

$$m_1 = 5.05 \text{ kg}$$

Choose direction of acceleration so that m_1 goes down and m_2 goes up.

$$\text{For } m_1: m_1 g - T = m_1 a \Rightarrow T = m_1 g - m_1 a$$

$$\text{For } m_2: T - m_2 g = m_2 a$$

$$\Rightarrow (m_1 g - m_1 a) - m_2 g = m_2 a$$

$$\Rightarrow m_1 g - m_2 g = m_1 a + m_2 a$$

$$\Rightarrow a = g \left(\frac{m_1 - m_2}{m_1 + m_2} \right) \quad \leftarrow \text{formula from example 3.8}$$

$$= (9.8) \left(\frac{5.05 - 5}{5.05 + 5} \right)$$

$$= 0.049 \text{ m/s}^2$$

$$y = v_i t + \frac{1}{2} a t^2$$

$$v_i = 0 \quad (\text{initial velocity})$$

$$\Rightarrow y = \frac{1}{2} a t^2$$

$$\Rightarrow t = \sqrt{\frac{2y}{a}} = \sqrt{\frac{2(0.08)}{0.049}} = 1.8 \text{ s}$$

(36) $F = \frac{G m_1 m_2}{r^2} \quad (\text{Eq 3.4})$

(3-36)

$$= (6.67 \times 10^{-11} \frac{\text{Nm}^2}{\text{kg}^2})(6 \times 10^{24} \text{ kg})(7.4 \times 10^{22} \text{ kg})$$

$$= (3.84 \times 10^8)^2$$

$$= 2 \times 10^{20} \text{ N}$$

(38) $r_N = 4r_E$ Object weighs w_E on earth. $w_N = ?$

(3-38) $m_N = 16m_E$

Let object have mass m_1 . $\Rightarrow w_E = m_1 g_E = \frac{G m_1 m_E}{r_E^2}$

$$w_N = m_1 g_N = \frac{G m_1 m_N}{r_N^2} = \frac{G m_1 (16m_E)}{(4r_E)^2} = \frac{16G m_1 m_E}{16r_E^2} = \frac{G m_1 m_E}{r_E^2} = w_E$$

Thus $w_E = w_N$

Since the object weighs the same on both planets, the acceleration due to gravity on Neptune is about the same as that of Earth $\approx 9.8 \text{ m/s}^2$

$$(m_1 g_E = m_1 g_N \Rightarrow g_E = g_N)$$

(39)



(3-39)

a) since speed is constant, total force on object must be zero.

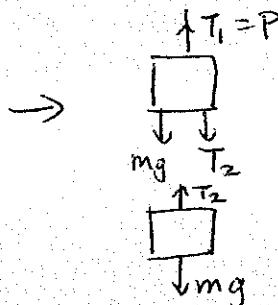
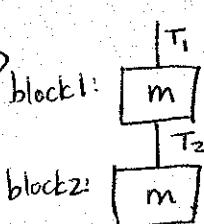
$$\Rightarrow T = mg = (20 \text{ kg})(9.8 \text{ m/s}^2) = 196 \text{ N}$$

b) $T - mg = ma$

$$\Rightarrow T = mg + ma = m(g+a) = (20)(9.8 + 0.7) = 210 \text{ N}$$

(43)

(3-43)



Write 2 eqns, 1 per block:

block 1: $ma = T_1 - T_2 - mg$

block 2: $ma = T_2 - mg$

$$\Rightarrow T_2 = ma + mg = m(a+g)$$

$$\Rightarrow [T_2 = m(a+g)] \quad \{ \text{EQN B}$$

Plug EQN B into the equation for block 1:

$$ma = T_1 - m(a+g) - mg$$

$$\Rightarrow T_1 = 2ma + 2mg$$

$$\Rightarrow [T_1 = 2m(a+g)] \quad \{ \text{EQN A}$$

Use EQN A to solve (a), (b), + (c):

a) $a=0$ since speed is constant.

$$\Rightarrow T_1 = 2 \cdot \frac{1}{2}(0+9.8) = 9.8 \text{ N}$$

b) $a=1.2 \text{ m/s}^2$

$$\Rightarrow T_1 = 2 \cdot \frac{1}{2}(1.2+9.8) = 11 \text{ N}$$

c) $a=-1.2 \text{ m/s}^2$

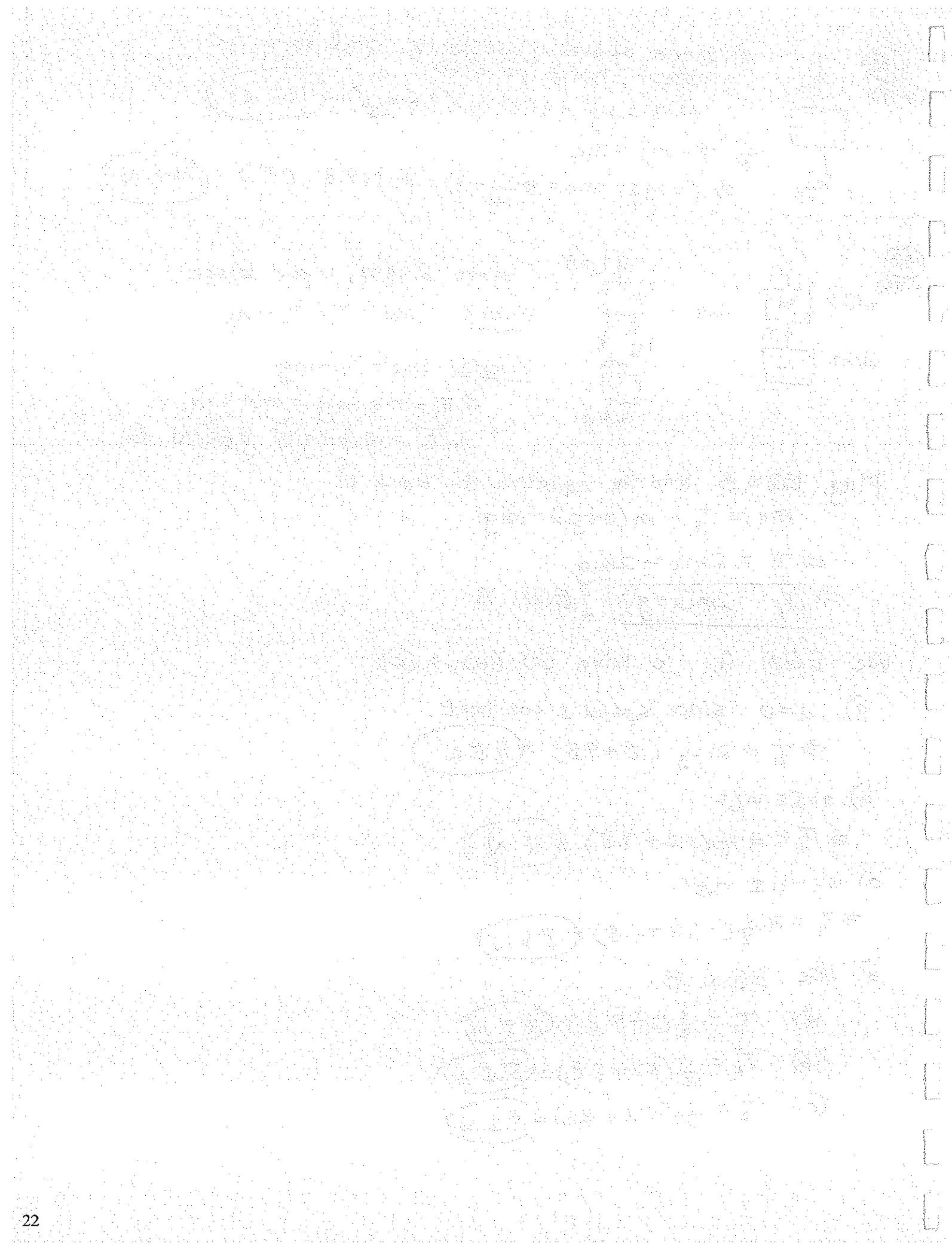
$$\Rightarrow T_1 = 2 \cdot \frac{1}{2}(-1.2+9.8) = 8.6 \text{ N}$$

d) Use EQN B:

(a) $T_2 = \frac{1}{2}(0+9.8) = 4.9 \text{ N}$

(b) $T_2 = \frac{1}{2}(1.2+9.8) = 5.5 \text{ N}$

(c) $T_2 = \frac{1}{2}(-1.2+9.8) = 4.3 \text{ N}$



Chp 4

- (3) The normal force on each block equals the vertical component of the force downward on the block.
- (4-3)

$$(a) i. F_N = mg = (10 \text{ kg})(9.8 \text{ m/s}^2) = 98 \text{ N}$$

$$ii. F_N = mg + P = 98 \text{ N} + 50 \text{ N} = 148 \text{ N}$$

$$iii. F_N = mg - P = 98 \text{ N} - 50 \text{ N} = 48 \text{ N}$$

$$iv. P_{\perp} = P \cos(30^\circ)$$

$$\Rightarrow F_N = mg + P \cos(30^\circ) = 98 \text{ N} + (50 \text{ N})\left(\frac{\sqrt{3}}{2}\right) = 141 \text{ N}$$

$$v. P_{\perp} = P \sin(30^\circ)$$

$$\Rightarrow F_N = mg - P \sin(30^\circ) = 98 \text{ N} - (50 \text{ N})\left(\frac{1}{2}\right) = 73 \text{ N}$$

$$(b) i. F_N = 40 \text{ lb}$$

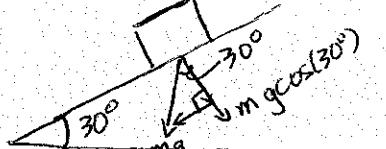
$$ii. F_N = 40 \text{ lb} + 30 \text{ lb} = 70 \text{ lb}$$

$$iii. F_N = 40 \text{ lb} - 30 \text{ lb} = 10 \text{ lb}$$

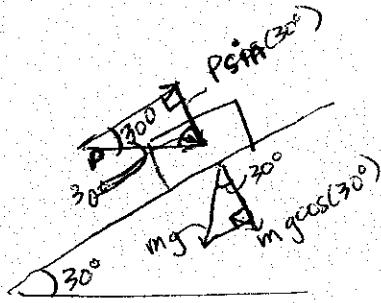
$$iv. F_N = 40 \text{ lb} + 30 \text{ lb} \left(\frac{\sqrt{3}}{2}\right) = 66 \text{ lb}$$

$$v. F_N = 40 \text{ lb} - 30 \text{ lb} \left(\frac{1}{2}\right) = 25 \text{ lb}$$

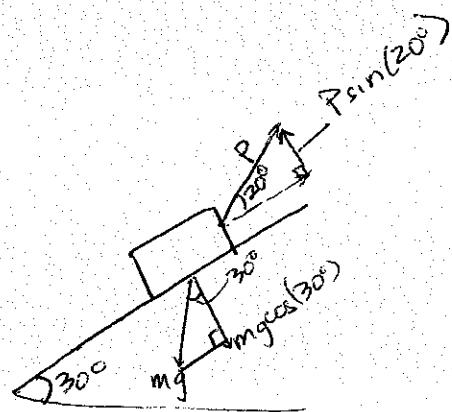
(4)
(4-4)



(i)



(iii)



(v)

Diagrams of vertical components of force on block (not including normal force) where "vertical" is taken to be \perp to the inclined surface

$$(a) i. F_N = mg \cos(30^\circ) = (10)(9.8)\left(\frac{\sqrt{3}}{2}\right) = 85 \text{ N}$$

$$ii. F_N = mg \cos(30^\circ) - P = 85 \text{ N} - 50 \text{ N} = 35 \text{ N}$$

$$iii. F_N = mg \cos(30^\circ) + P \sin(30^\circ) = 85 \text{ N} + 50 \text{ N} \left(\frac{\sqrt{3}}{2}\right) = 118 \text{ N}$$

$$iv. (P \text{ has no normal component}) \\ \Rightarrow F_N = mg \cos(30^\circ) = 85 \text{ N}$$

$$v. F_N = mg \cos(30^\circ) - P \sin(20^\circ) = 85 \text{ N} - (50 \text{ N})(0.34) = 68 \text{ N}$$

(4-4 cont...)

- (b) i) $F_N = (40 \text{ lb}) \cos(30^\circ) = 35 \text{ N}$
- ii) $F_N = (40 \text{ lb}) \cos(30^\circ) - 30 \text{ lb} = 5 \text{ N}$
- iii) $F_N = (40 \text{ lb}) \cos(30^\circ) + (30 \text{ lb}) \sin(30^\circ) = 50 \text{ N}$
- iv) $F_N = (40 \text{ lb}) \cos(30^\circ) = 35 \text{ N}$
- v) $F_N = (40 \text{ lb}) \cos(30^\circ) - (30 \text{ lb}) \sin(20^\circ) = 24 \text{ N}$

4-5) The normal force, F_N , is again determined from the equation $\sum F_{\perp} = 0$. Since the box does not slide parallel to the slope, the frictional force, f , is calculated from $\sum F_{\parallel} = 0$.

$$\sum F_{\perp} = F_N - mg \cos 37^\circ = 0$$

$$F_N = mg \cos 37^\circ = (50 \text{ kg})(9.8 \text{ m/s}^2)(0.8)$$

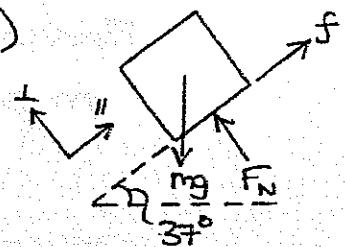
$$= 392 \text{ N.}$$

$$\sum F_{\parallel} = f - mg \sin 37^\circ = 0$$

$$f = mg \sin 37^\circ = (50 \text{ kg})(9.8 \text{ m/s}^2)(0.6)$$

$$= 294 \text{ N.}$$

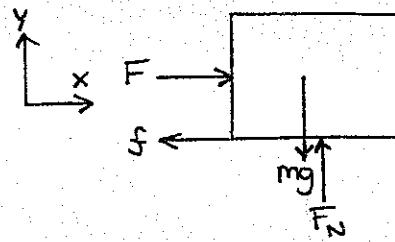
Note: f is not given by $\mu_s F_N$
(that is f^{\max} , only).



4-9) Since the box does not move vertically,

$$\sum F_y = F_N - mg = 0$$

$$F_N = mg = 800 \text{ N}.$$



To start the box moving, the applied force must just exceed the maximum static friction,

$$f_s^{\max} = \mu_s F_N = 0.8 \times 800 \text{ N} = 640 \text{ N}.$$

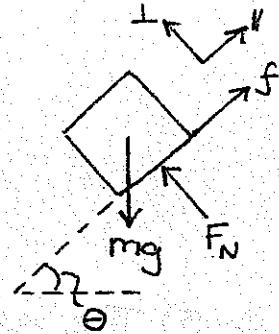
To keep the box moving at constant speed, the applied force must cancel the kinetic friction force,

$$f_k = \mu_k F_N = 0.6 \times 800 \text{ N} = 480 \text{ N}.$$

4-13) Let the angle between the slope and the horizontal be θ . Irrespective of whether the box is stationary or moving, we know

$$\sum F_L = F_N - mg \cos \theta = 0$$

$$\Rightarrow F_N = mg \cos \theta$$



(i) stationary box:

$$\sum F_{\parallel} = f_s - m g \sin \theta = 0$$

$$\Rightarrow f_s = m g \sin \theta \quad \text{but. } f_s^{\max} = \mu_s F_N = \mu_s m g \cos \theta$$

Therefore the box begins to slip when

$$m g \sin \theta > f_s^{\max} \quad \text{or} \quad m g \sin \theta > \mu_s m g \cos \theta \\ \text{or} \quad \tan \theta > \mu_s$$

We are told the box slips when θ exceeds 50° .

$$\Rightarrow \mu_s = \tan 50^\circ = 1.19.$$

Note: μ does not have to be less than one.

(ii) moving box :

$$\sum F_{\parallel} = f_k - mg \sin \theta = ma \quad \text{where } f_k = \mu_k F_N = \mu_k mg \cos \theta.$$

$$\Rightarrow a = (\mu_k \cos \theta - \sin \theta) g.$$

The box will continue moving down the slope until the angle θ is reduced sufficiently that a becomes positive (since the velocity is in the negative \parallel direction).
i.e., stops when

$$0 = (\mu_k \cos \theta - \sin \theta) g \quad \text{or} \quad \tan \theta = \mu_k.$$

We are told the box stops for $\theta \leq 40^\circ$.

$$\Rightarrow \mu_k = \tan 40^\circ = 0.84.$$

A-14) The force P has components

$$P_x = P \cos 37^\circ, P_y = -P \sin 37^\circ.$$

$$\sum F_x = P \cos 37^\circ - f = ma$$

$$\sum F_y = F_N - mg - P \sin 37^\circ = 0$$

$$\Rightarrow F_N = mg + P \sin 37^\circ.$$

(i) Stationary box: when $P=190N$ it just overcomes a friction force $f = f_s^{\max} = \mu_s F_N$; i.e., we can set $a=0$

$$\Rightarrow f_s^{\max} = P \cos 37^\circ$$

$$\mu_s = \frac{P \cos 37^\circ}{F_N} = \frac{(190N) \cos 37^\circ}{300N + (190N) \sin 37^\circ} = 0.37.$$

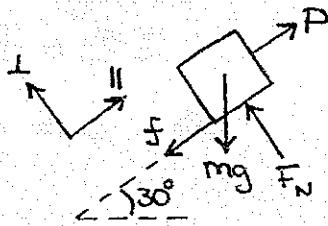
(ii) Moving box: when $P=120N$ it balances a friction force $f = f_k = \mu_k F_N$ so that $a=0$ again.

$$\Rightarrow \mu_k = \frac{P \cos 37^\circ}{F_N} = \frac{(120N) \cos 37^\circ}{300N + (120N) \sin 37^\circ} = 0.26.$$

4-19) As usual, we determine F_N from

$$\sum F_{\perp} = F_N - mg \cos \theta = 0$$

$$F_N = mg \cos \theta$$



Since the box moves up the slope at constant speed, we know

$$a = 0 \quad \text{and} \quad f = -\mu_k F_N$$

$$\text{Thus } \sum F_{\parallel} = P - mg \sin \theta - \mu_k F_N = 0$$

$$\begin{aligned} P &= mg \sin \theta + \mu_k F_N = mg (\sin \theta + \mu_k \cos \theta) \\ &= (5.0 \text{ kg})(9.8 \text{ m/s}^2)(\sin 30^\circ + 0.40 \cos 30^\circ) \\ &= \boxed{41.5 \text{ N.}} \end{aligned}$$

4-25) (a) This part requires the constant acceleration formulae from Chapter 2. We know $v_i = 80 \text{ cm/s}$, $v_f = 0 \text{ cm/s}$, and $x = 60 \text{ cm}$.

$$\text{Using } v_f^2 = v_i^2 + 2ax, \quad a = \frac{v_f^2 - v_i^2}{2x} = \frac{0^2 - 80^2 (\text{cm/s})^2}{2 \times 60 \text{ cm}} = -53.3 \text{ cm/s}^2 = \boxed{-0.53 \text{ m/s}^2}.$$

(b) This part requires Newton's 2nd law from Chapter 3:

$$F = ma = (0.5 \text{ kg})(-0.53 \text{ m/s}^2) = -0.27 \text{ N.}$$

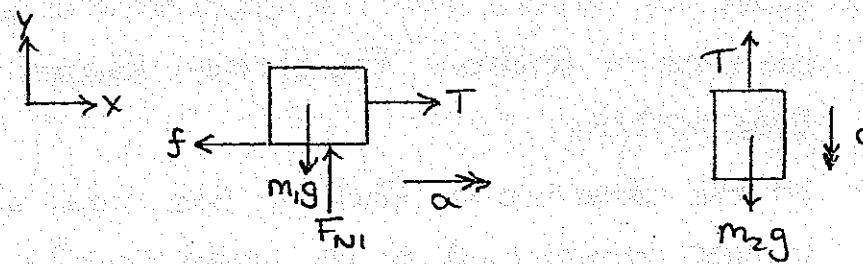
Since the question asks how big the force is, we need its magnitude, $\boxed{0.27 \text{ N.}}$

(c) For an object resting on a horizontal surface with only gravity and F_N acting vertically, $F_N = mg$.

$$\Rightarrow \mu_k = \frac{\text{frictional force}}{mg} = \frac{0.27 \text{ N}}{(0.5 \text{ kg})(9.8 \text{ m/s}^2)} = \boxed{0.054}$$

(Note: mass must be converted to kg to get forces in N.)

4-27) Hint: Just as in Chapter 3, coupled objects require separate free-body diagrams.



We assume that mass m_2 falls with acceleration a . Since mass m_1 is attached by a string, it has a horizontal acceleration a . Also, take $\mu_k = \mu_s = 0.4$ or 0.8 .

$$\text{For } m_1: m_1 a = \sum F_x = T - f$$

$$0 = \sum F_y = F_{N1} - m_1 g$$

$$\text{If } m_1 \text{ is actually moving, } f = \mu_k F_{N1} \text{ and } m_1 a = T - \mu_k m_1 g \quad (1)$$

$$\text{For } m_2: m_2(-a) = \sum F_y = T - m_2 g \quad \text{or} \quad -m_2 a = T - m_2 g \quad (2)$$

(a) Solving simultaneous equations (1) and (2), with $\mu_k = 0.4$:

$$a = \frac{m_2 - \mu_k m_1}{m_2 + m_1} g = \frac{2.0 - 0.4 \times 3.0}{2.0 + 3.0} \times 9.8 \text{ m/s}^2 = 1.57 \text{ m/s}^2.$$

$$T = \frac{(1+\mu_k)m_1 m_2 g}{m_1 + m_2} = \frac{(1+0.4)(3.0 \text{ kg})(2.0 \text{ kg})(9.8 \text{ m/s}^2)}{(3.0 + 2.0) \text{ kg}} = 16.5 \text{ N.}$$

(b) In (a), the reason the masses accelerate as shown is that the weight of mass m_2 exceeds the maximum frictional force $\mu_s m_1 g$ holding back mass m_1 .

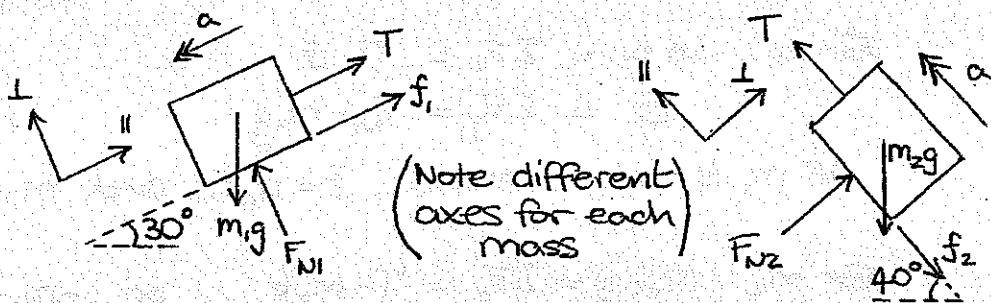
When μ_s increases to 0.8 , $\mu_s m_1 g = 23.5 \text{ N}$ exceeds $m_2 g = 19.6 \text{ N}$. Therefore the masses do not move.

$$\Rightarrow a = 0 \text{ m/s}^2, \quad T = m_2 g = 19.6 \text{ N.}$$

4-29) Hint. Think carefully which way friction acts on the masses.

Method: Work out which way the coupled masses move in the absence of friction. The friction forces act to oppose this motion.

In the absence of friction, the mass with the larger component of its weight parallel to its slope will move downwards. Since $m_1 g \sin 30^\circ = 49.0 \text{ N}$ and $m_2 g \sin 40^\circ = 18.9 \text{ N}$, mass m_1 falls, m_2 rises.



$$m_1: m_1 a = T - m_1 g \sin 30^\circ + f_1 = T - m_1 g (\sin 30^\circ - \mu_k \cos 30^\circ)$$

$$m_2: m_2 a = T - m_2 g \sin 40^\circ - f_2 = T - m_2 g (\sin 40^\circ + \mu_k \cos 40^\circ)$$

Once again we are left with simultaneous equations for T and a . One way to solve is to subtract the 1st equation from the second:

$$(m_1 + m_2)a = m_1 g (\sin 30^\circ - \mu_k \cos 30^\circ) - m_2 g (\sin 40^\circ + \mu_k \cos 40^\circ)$$

$$(13.0 \text{ kg})a = (98 \text{ N})(\sin 30^\circ - 0.2 \cos 30^\circ) - (29.4 \text{ N})(\sin 40^\circ + 0.2 \cos 40^\circ)$$

$$= 8.6 \text{ N}$$

$$a = \frac{8.6 \text{ N}}{13.0 \text{ kg}} = \boxed{0.66 \text{ m/s}^2}$$

Substituting for a into the second equation, and rearranging,

$$T = m_2 a + m_2 g (\sin 40^\circ + \mu_k \cos 40^\circ)$$

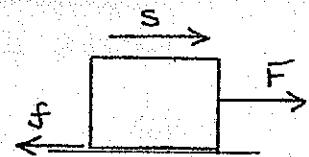
$$= (3.0 \text{ kg})(0.66 \text{ m/s}^2) + (3.0 \text{ kg})(9.8 \text{ m/s}^2)(\sin 40^\circ + 0.2 \times \cos 40^\circ)$$

$$= \boxed{25.4 \text{ N}}$$

Chapter 5 (2, 7, 12, 16, 19, 21, 31, 36, 37, 39, 40, 45)

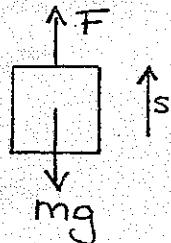
5-2) In each part of this problem we must carefully consider the relative directions of the force, F , and the displacement, s , entering the definition of the work done.

- (a) The force F is equal in magnitude to the frictional force $f = 40\text{ N}$, since the object moves at constant speed ($a = 0$).



$$\begin{aligned} \text{work, } W &= Fs \quad (\text{since the vectors point in the same direction}) \\ &= (40\text{ N})(0.3\text{ m}) \\ &= \boxed{12\text{ J.}} \end{aligned}$$

- (b) If the object is lifted slowly enough that we can take $a = 0$, then the force F is equal in magnitude to the object's weight.

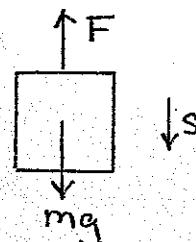


$$\begin{aligned} \text{work, } W &= Fs = mgs \\ &= (5.0\text{ kg})(9.8\text{ m/s}^2)(0.3\text{ m}) \\ &= \boxed{14.7\text{ J.}} \end{aligned}$$

- (c) As in (b), $W = mgs = (6.0\text{ kg})(9.8\text{ m/s}^2)(0.6\text{ m})$
- $$= \boxed{35.3\text{ J.}}$$

- (d) This is the situation in (c) but with s reversed: Therefore the work has the opposite sign.

$$\text{work, } W = \boxed{-35.3\text{ J.}}$$



- (e) Since the displacement is zero,
- $$\text{work, } W = \boxed{0.}$$

5-7) The force acts at an angle of 37° to the displacement, which is parallel to the floor.

$$\Rightarrow \text{work, } W = (90\text{N})(8\text{m}) \cos 37^\circ = 575\text{N.}$$

5-12) Increase in gravitational potential energy is $\Delta E_p = mg\Delta h$, where $\Delta h = \text{increase in object's height (no matter how achieved)}$

(a) $\Delta E_p = (700\text{kg})(9.8\text{m/s}^2)(20\text{m}) = 140\text{kJ.}$

(b) $\Delta E_p = 0$ (since $\Delta h = 0$).

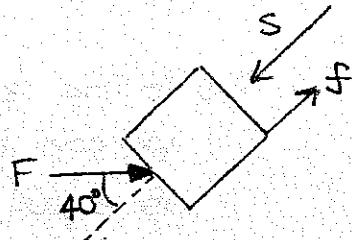
(c) $\Delta E_p = (700\text{kg})(9.8\text{m/s}^2)(-20\text{m}) = -140\text{kJ.}$

5-16)(a) From the definition, work = $Fs \cos\theta$.

The angle between F and s is

$$\theta = 180^\circ - 40^\circ = 140^\circ.$$

$$\Rightarrow W = (500\text{N})(2\text{m}) \cos 140^\circ = -766\text{J.}$$



(b) Box is lowered a distance $(2\text{m}) \sin 40^\circ = 1.29\text{m.}$

(c) $\Delta E_p = mg\Delta h = (70\text{kg})(9.8\text{m/s}^2)(-1.29\text{m}) = -882\text{J.}$
↑ lowered

(d) From conservation of mechanical energy

$$\Delta E_k + \Delta E_p = \text{work done by outside forces (F and f)}$$

We assume $\Delta E_k = 0$ since the box moves "slowly."

Also, we know that work done by friction is $-fs$.

Substituting work done by F and ΔE_p from above,

$$-882\text{J} = -766\text{J} - f(2\text{m})$$

$$\Rightarrow \text{friction force, } f = 58\text{N.}$$

5-19) Power, $P = Fv \cos\theta$.

Here $F = mg$ (because lift load at constant speed)

and $\theta = 0^\circ$ (because F and v both point straight up).

$$\Rightarrow P = mgv$$

$$v = \frac{P}{mg} = \frac{(2\text{hp}) \times \left(\frac{746\text{W}}{1\text{hp}}\right)}{(100\text{kg}) \times (9.8\text{m/s}^2)} = 1.5\text{ m/s}^2$$

5-21) Hint: This is not really a ** problem.

Since the car is moving at constant speed on a level road, there is no change in the kinetic energy or the gravitational potential energy. Thus all the work done by the motor goes to overcome friction:

$$\text{friction force} = \text{driving force, } F = \frac{P}{v}$$

$$= \frac{(45\text{hp}) \times \left(\frac{746\text{W}}{1\text{hp}}\right)}{\left(100\frac{\text{km}}{\text{h}}\right) \times \left(\frac{1000\text{m}}{1\text{km}}\right) \times \left(\frac{1\text{h}}{3600\text{s}}\right)} = 1210\text{N}$$

5-31) Hint: The problem is clearer if you delete the word "nearly".

In the absence of friction, no outside force other than gravity acts on the block as it slides down the incline. Thus, by conservation of energy,

$$E_{kf} + E_{pf} = E_{ki} + E_{pi} + W_{nc}$$

$$\frac{1}{2}mv_f^2 + 0 = 0 + mgh$$

$$\text{velocity at bottom, } v_f = \sqrt{2gh} = \sqrt{2(9.8\text{m/s}^2)(0.3\text{m})} = 2.42\text{ m/s.}$$

5-36) We are told that the slope in 5-31 was not frictionless after all, so we must allow for a friction force f doing work $W_{nc} = -fs$ where s is the distance slid.

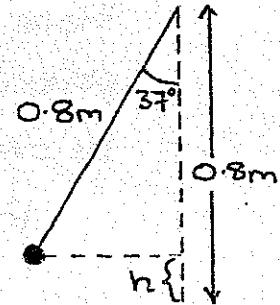
By conservation of mechanical energy,

$$\begin{aligned} E_{kf} + E_{pf} &= E_{ki} + E_{pi} + W_{nc} \\ \frac{1}{2}mv_f^2 + 0 &= 0 + mgh - fs \\ f &= \frac{mgh - \frac{1}{2}mv_f^2}{s} = \frac{m}{s}(gh - \frac{1}{2}v_f^2) \\ &= \frac{3.0\text{kg}}{2.0\text{m}} [(9.8\text{m/s}^2)(0.3\text{m}) - \frac{1}{2}(1.20\text{m/s})^2] = 3.33\text{ N.} \end{aligned}$$

- 5-37) At its initial position, the pendulum ball is a height $h = (0.8\text{m})(1-\cos 37^\circ) = 0.16\text{m}$ above its lowest point.

The only outside force acting on the ball is the tension in the string. This acts at 90° to the direction of motion, so it does no work ($\cos 90^\circ = 0$).

$$\begin{aligned} \Rightarrow E_{kf} + E_{pf} &= E_{ki} + E_{pi} + \overset{\uparrow}{W_{nc}} \\ \frac{1}{2}mv_f^2 + 0 &= 0 + mgh \quad (\text{result independent of } m) \\ v_f &= \sqrt{2gh} = \sqrt{2(9.8\text{m/s}^2)(0.16\text{m})} = 1.77\text{ m/s.} \end{aligned}$$



After passing the lowest point, the ball will carry on until it reaches a height where all its kinetic energy has been converted to gravitational potential energy. Clearly, this is just the height at which it was first released, which was 0.16m above the lowest point.

- 5-39) By conservation of mechanical energy

$$\begin{aligned} E_{kf} + E_{pf} &= E_{ki} + E_{pi} + W_{nc} \\ 0 + 0 &= 0 + mgh - fs \quad (\text{initial and final velocity} = 0) \\ \text{friction force, } f &= \frac{mgh}{s} = \frac{(2.0\text{kg})(9.8\text{m/s}^2)(1.5\text{m})}{30\text{m}} = 0.98\text{ N.} \end{aligned}$$

5-40) In the absence of friction, the only outside force is at 90° to the direction of motion, and hence does no work.

$$\text{Thus } E_{kf} + E_{pf} = E_{ki} + E_{pi} + W_{\text{ext}}^0$$

$$\frac{1}{2}mv_f^2 + mgh_f = 0 + mgh_i$$

$$v_f = \sqrt{2g(h_i - h_f)}$$

$$\text{At point C, } v_f = \sqrt{2(9.8 \text{ m/s}^2)(2.0 - 1.0 \text{ m})} = 4.4 \text{ m/s.}$$

$$\text{At point D, } v_f = \sqrt{2(9.8 \text{ m/s}^2)(2.0 - 0.5 \text{ m})} = 5.4 \text{ m/s.}$$

5-45) The increase in gravitational potential energy of the water on going from the lake to the tank is

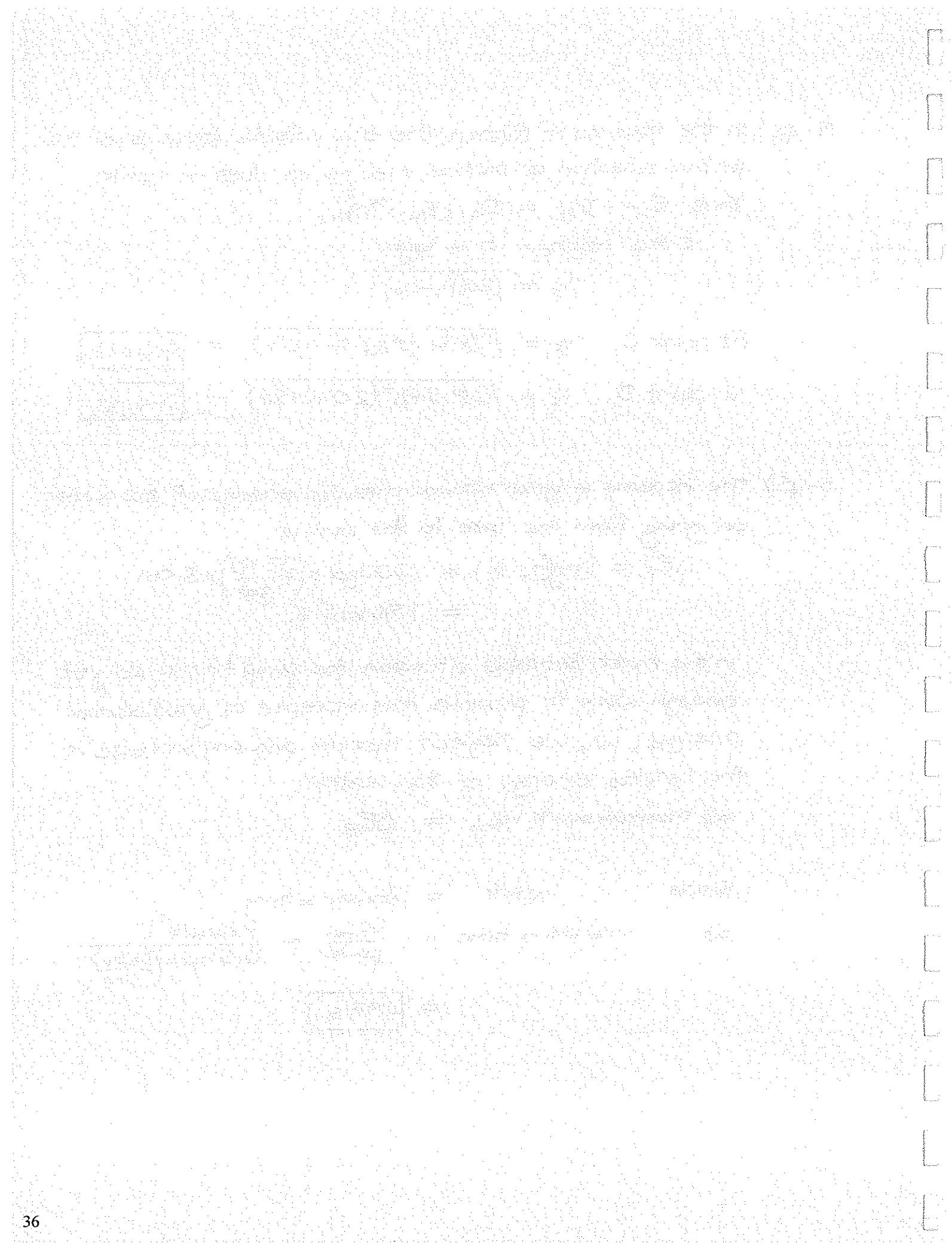
$$\begin{aligned}\Delta E_p &= (mg)(h_f - h_i) = 1000 \text{ gal} \times \left(\frac{37.1 \text{ N}}{1 \text{ gal}}\right) \times 5.0 \text{ m} \\ &= 1.86 \times 10^5 \text{ J.}\end{aligned}$$

In the most favorable situation, the pump has to do just enough work to provide this increase in gravitational energy, i.e., we neglect friction and any increase in the kinetic energy of the water.

$$\Rightarrow \text{minimum work, } W_{\min} = \Delta E_p$$

Since work = power \times time,

$$\begin{aligned}\Rightarrow \text{minimum time} &= \frac{W_{\min}}{\text{power}} = \frac{1.86 \times 10^5 \text{ J}}{0.5 \text{ shp} \times \left(\frac{746 \text{ W}}{1 \text{ hp}}\right)} \\ &= 497 \text{ s.}\end{aligned}$$



Chapter 6 (2, 3, 5, 7, 11, 15, 18, 19, 20, 22, 26, 33)

6-2) We are given $F_i = 30N$, $F_o = 500N$, $s_i = 12m$, $s_o = 0.5m$.

$$\text{IMA} = \frac{s_i}{s_o} = \frac{12m}{0.5m} = 24 \quad \left. \begin{array}{l} \\ \end{array} \right\} \text{efficiency} = \frac{\text{AMA}}{\text{IMA}} = 0.69$$

$$\text{AMA} = \frac{F_o}{F_i} = \frac{500N}{30N} = 16.7$$

6-3) We are given $F_i = 50N$, $s_i = 1.50m$, $s_o = 0.042m$, eff. = 0.40.

$$\text{IMA} = \frac{s_i}{s_o} = \frac{1.50m}{0.042m} = 35.7$$

$$\begin{aligned} \text{load, } F_o &= \text{AMA} \times F_i = (\text{efficiency} \times \text{IMA}) \times F_i \\ &= (0.40 \times 35.7) \times 50N = 714N. \end{aligned}$$

6-5) Since the machines are 100% efficient, we can write

$$\text{AMIA} = \text{IMA} \Rightarrow \frac{F_o}{F_i} = \frac{s_i}{s_o} \Rightarrow F_i = \frac{s_i}{s_o} F_o.$$

1st kind: When F_i moves down one unit of distance, w moves up one unit. Thus,

$$\text{IMA} = \frac{1}{1} = 1 \quad \text{and} \quad F_i = w.$$

2nd kind: When F_i moves up one unit, w moves up half a unit.

$$\text{IMA} = \frac{1}{\frac{1}{2}} = 2 \quad \text{and} \quad F_i = \frac{w}{2}.$$

3rd kind: When F_i moves up one unit, w moves up two units.

$$\text{IMA} = \frac{1}{2} \quad \text{and} \quad F_i = 2w.$$

6-7) Since efficiency = $\frac{P_o}{P_i}$, $P_o = \text{efficiency} \times P_i$.

From Chapter 5, we know that in order to lift a weight w,

$$F_o = w \quad \text{and} \quad P_o = F_o V = wV$$

$$\Rightarrow w = \frac{P_o}{V} = \frac{\text{efficiency} \times P_i}{V} = \frac{0.85 \times 140W}{0.08 \text{m/s}} = 1.5 \text{kN.}$$

6-11) The wheelbarrow is a lever of the second kind. We are told that the input force is applied at a distance from the fulcrum four times greater than the output force.

$$\Rightarrow \text{IMA} = \frac{s_i}{s_o} = 4.$$

Assuming 100% efficiency, $\text{AMA} = \text{IMA}$

$$\Rightarrow F_i = \frac{F_o}{\text{IMA}} = \frac{1000\text{N}}{4} = 250\text{N}.$$

6-15) We are given $F_i = 100\text{N}$, $F_o = 500\text{N}$, $s_i = 24\text{cm}$, $s_o = 3\text{cm}$.

$$\begin{aligned} \text{IMA} &= \frac{s_i}{s_o} = \frac{24\text{cm}}{3\text{cm}} = 8 \\ \text{AMA} &= \frac{F_o}{F_i} = \frac{500\text{N}}{100\text{N}} = 5 \end{aligned} \quad \left. \begin{array}{l} \text{efficiency} = \frac{\text{AMA}}{\text{IMA}} = 0.625. \end{array} \right\}$$

6-18) Since five ropes support the load, the input force moves a distance five times that moved by the output force.

$$\Rightarrow \text{IMA} = \frac{s_i}{s_o} = 5.$$

$$\begin{aligned} \text{load, } F_o &= \text{AMA} \times F_i = (\text{efficiency} \times \text{IMA}) \times F_i \\ &= (0.90 \times 5) \times 500\text{N} = 2250\text{N}. \end{aligned}$$

6-19) When asked to analyze a pulley system, you should always count the number of separate pieces of rope. If there are two or more ropes, it is a compound machine, rather than a simple machine.

In this problem there are three strings, and hence three simple pulleys, combined into a compound machine. The output force of the top pulley forms the input for the middle pulley, while the output of the middle pulley acts as the input for the bottom pulley.

Suppose the input force is moved a distance s_i . The top pulley will move $s_i/2$, the middle pulley $s_i/4$, and the bottom pulley just $s_i/8$. Since the load hangs from the bottom pulley,

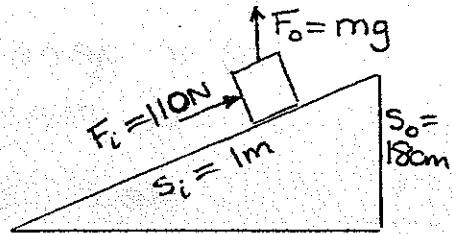
$$S_o = s_i/8$$

$$\Rightarrow \text{IMA} = \frac{s_i}{S_o} = 8.$$

$$6-20) \text{ IMA} = \frac{s_i}{S_o} = \frac{1m}{0.125m} = 8.$$

$$\text{AMA} = \frac{F_o}{F_i} = \frac{(30\text{kg})(9.8\text{m/s}^2)}{110\text{N}} = 2.7.$$

$$\text{efficiency} = \frac{\text{AMA}}{\text{IMA}} = 0.48.$$



$$6-22) \text{ In a hydraulic press, } \text{IMA} = \frac{A_o}{A_i}.$$

Since the area of a circle is $A = \frac{\pi}{4}d^2$ (d =diameter),

$$\text{IMA} = \frac{d_o^2}{d_i^2} = \frac{(8.0\text{cm})^2}{(0.375\text{cm})^2} = 455.$$

Assuming 100% efficiency, $\text{AMA} = \text{IMA}$.

$$\Rightarrow F_i = \frac{F_o}{\text{IMA}} = \frac{60,000\text{N}}{455} = 132\text{N}.$$

$$6-26) \text{ In an ideal belt-and-gear system,}$$

$$\text{IMA} = \frac{\text{torque out}}{\text{torque in}} = \frac{\text{input rotation rate}}{\text{output rotation rate}}$$

$$\text{In this problem, } \text{IMA} = \frac{1720 \text{ rev/min} \times \left(\frac{1 \text{ min}}{60 \text{ sec}}\right)}{2.0 \text{ rev/sec}}$$

$$= 14.3.$$

If friction can be ignored, this is the factor by which the gear system multiplies the torque.

6-33) (a) The object rises 1m when pushed 10m along the incline.

$$\Rightarrow \text{IMA of incline} = \frac{s_i}{s_o} = \frac{10\text{m}}{1\text{m}} = 10.$$

(b) Two strands of rope connect to the moving pulley.

$$\Rightarrow \text{IMA of block and tackle} = 2.$$

(c) In general, IMA of compound machine = product of IMA's of constituent machines.

Here, overall IMA = $10 \times 2 = 20$.

Note: You should go back and check that you can apply this method for calculating the IMA to the compound machine in 6-19.

Chapter 7 (2, 5, 11, 17, 21, 22, 26, 29, 30, 36, 39)

7-2) Momentum is a vector: $\vec{P} = m\vec{V}$,

$$\text{i.e., } P_x = mv_x = (1000 \text{ kg})(30 \text{ km/h}) \left(\frac{1000 \text{ m}}{1 \text{ km}} \times \frac{1 \text{ h}}{3600 \text{ s}} \right) \\ = 8333 \text{ kg} \cdot \text{m/s}$$

$$P_y = mv_y = 0 \text{ kg} \cdot \text{m/s.}$$

7-5)(a) From Chapters 2 and 6 we know that the ball's velocity just before it strikes the floor is

$$v_{iy} = -\sqrt{2gh_1} = -\sqrt{2(9.8 \text{ m/s}^2)(0.8 \text{ m})} = -3.96 \text{ m/s.}$$

$$\Rightarrow P_{iy} = mv_{iy} = (0.02 \text{ kg})(-3.96 \text{ m/s}) = -0.079 \text{ kg} \cdot \text{m/s.}$$

(b) Similarly, the velocity immediately after the rebound is

$$v_{fy} = +\sqrt{2gh_2} = \sqrt{2(9.8 \text{ m/s}^2)(0.6 \text{ m})} = 3.43 \text{ m/s.}$$

$$\Rightarrow P_{fy} = mv_{fy} = (0.02 \text{ kg})(3.43 \text{ m/s}) = 0.069 \text{ kg} \cdot \text{m/s.}$$

$$(c) \Delta P_y = P_{fy} - P_{iy} = -0.079 - 0.069 \text{ kg} \cdot \text{m/s} = 0.148 \text{ kg} \cdot \text{m/s.}$$

7-11) Impulse is a vector: $(\vec{F}t) = m(\vec{V}_f - \vec{V}_i)$,

$$\text{i.e., } (\vec{F}t)_x = m(v_{fx} - v_x) = (0.02 \text{ kg})(-2.0 \text{ m/s} - 3.0 \text{ m/s}) \\ = -0.10 \text{ kg} \cdot \text{m/s or } -0.10 \text{ N.s.}$$

$$(\vec{F}t)_y = m(v_{fy} - v_{iy}) = 0 \text{ N.s.}$$

Thus, the impulse is 0.10 N.s, directed along the $-x$ direction.

7-17)(a) We can use the constant acceleration formulae from Chapter 2. We know $v_i = 400 \text{ m/s}$, $v_f = 0 \text{ m/s}$, $x = 0.08 \text{ m}$.

$$\text{Since } x = \bar{v}t = \frac{1}{2}(v_i + v_f)t \Rightarrow t = \frac{2x}{v_i + v_f} = \frac{2 \times 0.08 \text{ m}}{(400 + 0) \text{ m/s}}$$

$$= 4.0 \times 10^{-4} \text{ s.}$$

$$(b) \text{ Using } \bar{F}t = m(v_f - v_i), \quad \bar{F} = \frac{m(v_f - v_i)}{t}$$

$$= \frac{(0.02 \text{ kg})(0 - 400 \text{ m/s})}{4.0 \times 10^{-4} \text{ s}}$$

$$= -2.0 \times 10^4 \text{ N.}$$

7-21) This is a perfectly inelastic collision in one dimension. The common velocity, v , after the collision is given by conservation of momentum:

$$m_{\text{boy}} v_{\text{boy}} + m_{\text{girl}} v_{\text{girl}} = (m_{\text{boy}} + m_{\text{girl}}) v$$

$$v = \frac{m_{\text{boy}} v_{\text{boy}} + m_{\text{girl}} v_{\text{girl}}}{m_{\text{boy}} + m_{\text{girl}}}$$

$$= \frac{(70 \text{ kg})(4.0 \text{ m/s}) + (50 \text{ kg})(0 \text{ m/s})}{(70 + 50) \text{ kg}}$$

$$= 2.3 \text{ m/s.}$$

7-22) This is also a one-dimensional momentum conservation problem - this time of the recoil or rocket type, with zero initial momentum:

$$0 = m_{\text{rifle}} v_{\text{rifle}} + m_{\text{bullet}} v_{\text{bullet}}$$

$$v_{\text{rifle}} = -\frac{m_{\text{bullet}}}{m_{\text{rifle}}} v_{\text{bullet}} = -\frac{0.025 \text{ kg}}{1.8 \text{ kg}} \times 500 \text{ m/s}$$

$$= -4.5 \text{ m/s.}$$

7-26) Let the 1200-kg car be mass 1. By momentum conservation,

$$m_1 V_{1i} + m_2 V_{2i} = m_1 V_{1f} + m_2 V_{2f}$$

$$\Rightarrow V_{1f} = \frac{m_1 V_{1i} + m_2 (V_{2i} - V_{2f})}{m_1} = \frac{(1200\text{kg})(4.0\text{m/s}) + (700\text{kg})(0 - 5.0\text{m/s})}{1200\text{kg}}$$
$$= 1.1\text{ m/s.}$$

7-29) By conservation of momentum

$$m_A V_{Ai} + m_B V_{Bi} = m_A V_{Af} + m_B V_{Bf}$$

$$\Rightarrow V_{Bf} = \frac{m_B V_{Bi} + m_A (V_{Ai} - V_{Af})}{m_B} = \frac{-2.0\text{ m/s} + (3.0 - (-1.5))\text{m/s}}{1}$$
$$= 2.5\text{ m/s.}$$

If the collision is perfectly elastic, it must obey the velocity equation

$$\begin{aligned} V_{Af} + V_{Ai} &= V_{Bf} + V_{Bi} \\ -1.5 + 3.0 &\stackrel{?}{=} 2.5 - 2.0 \quad \text{No!} \end{aligned}$$

The collision is not perfectly elastic.

7-30) The final velocities must satisfy both momentum conservation and the velocity equation. For equal masses we obtain

$$V_{Ai} + V_{Bi} = V_{Af} + V_{Bf}$$

and

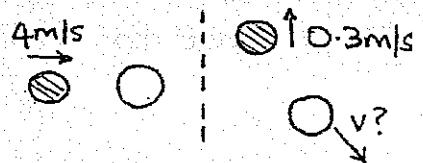
$$V_{Af} + V_{Ai} = V_{Bf} + V_{Bi}.$$

As shown in Example 7.10, the solution is

$$V_{Af} = V_{Bi} = -2.0\text{ m/s}$$

$$V_{Bf} = V_{Ai} = 3.0\text{ m/s.}$$

7-36) Momentum is conserved separately in the x- and y-directions



$$x: (1.8 \text{ kg})(4.0 \text{ m/s}) + (3.0 \text{ kg})(0 \text{ m/s}) = (1.8 \text{ kg})(0 \text{ m/s}) + (3.0 \text{ kg})V_x$$

$$V_x = \frac{1.8 \times 4.0}{3.0} \text{ m/s} = 2.4 \text{ m/s.}$$

$$y: (1.8 \text{ kg})(0 \text{ m/s}) + (3.0 \text{ kg})(0 \text{ m/s}) = (1.8 \text{ kg})(0.3 \text{ m/s}) + (3.0 \text{ kg})V_y$$

$$V_y = -\frac{1.8 \times 0.3}{3.0} \text{ m/s} = -0.18 \text{ m/s.}$$

7-39) Method: ① We calculate the velocity of ball A just before the collision, using energy conservation. ② We compute the velocity of ball B right after the collision using momentum conservation. ③ We calculate the height reached by ball B using energy conservation again.

① In "falling" through a vertical height $h_A = 20 \text{ cm}$, ball A attains a velocity $V_A = \sqrt{2gh_A} = \sqrt{2(9.8 \text{ m/s}^2)(0.2 \text{ m})} = 1.98 \text{ m/s}$

② After a perfectly elastic collision with a stationary ball B, the velocities V_A' and V_B' are given by

$$m_A V_A + 0 = m_A(V_A' + \frac{m_B V_B'}{m_A}) \quad \text{momentum}$$

$$V_A' + V_A = V_B' + 0 \quad \text{velocity equation}$$

$$\text{Adding, } V_A' + 2V_A = V_A' + (1 + \frac{m_B}{m_A})V_B'$$

$$V_B' = \frac{2m_A}{m_A + m_B} V_A = \frac{2}{3} \times 1.98 \text{ m/s} \\ = 1.32 \text{ m/s.}$$

③ Ball B will rise to a height

$$h_B = \frac{V_B'^2}{2g} = \frac{(1.32 \text{ m/s})^2}{2 \times 9.8 \text{ m/s}^2} = 0.089 \text{ m} = 8.9 \text{ cm.}$$

Chapter 8 (3, 5, 7, 13, 15, 17, 19, 20, 21, 26, 32, 37, 43)

8-3) The forces balance out when they satisfy

$$\vec{F}_1 + \vec{F}_2 + \vec{F}_3 = \vec{0}.$$

We know

$$\vec{F}_1 = 25\text{N at } 90^\circ = (0, 25) \text{ N}$$

$$\vec{F}_2 = 70\text{N at } 270^\circ = (0, -70) \text{ N}$$

$$\Rightarrow \vec{F}_3 = -\vec{F}_1 - \vec{F}_2 = -(0, 25) \text{ N} - (0, -70) \text{ N}$$

$$= (0, 45) \text{ N or } 45 \text{ N at } 90^\circ.$$

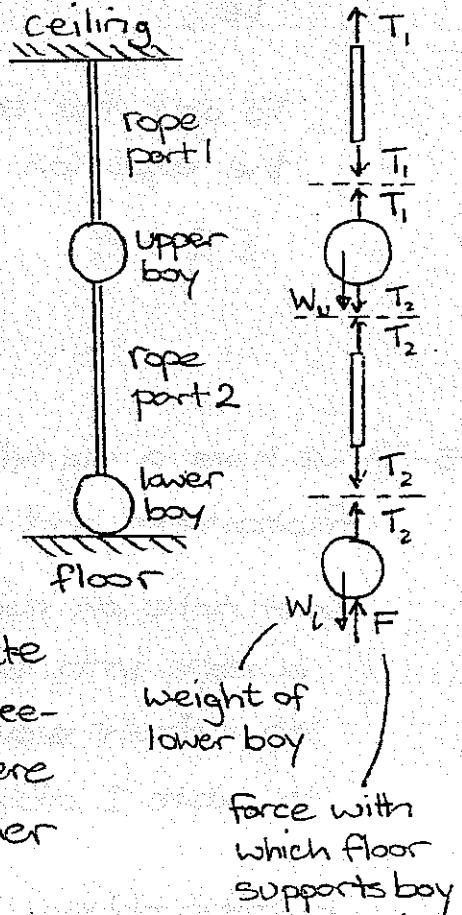
8-5) Although this is a simple problem,

it is instructive to look at the solution in detail because it is important you understand how to treat ropes and strings.

On the far right there are "free-body" diagrams for the things that can move : the two boys, and the different segments of the rope.

Note 1: A rope is broken into separate segments, requiring their own free-body diagrams, at any point where it is held or attached to any other object (including another rope).

Note 2: The free-body diagram for a rope segment is very simple: it just has the tension vector pointing outwards from each end of the segment.



(It is so simple that we don't usually draw it explicitly.)

Note 3: The object connected to the end of a rope segment always experiences a force equal to the tension in the rope, directed away from the object along the direction of the rope.

Looking at the bottom two free-body diagrams, we see that the tension in the lower segment is equal to the force exerted by the lower boy,

i.e.,

$$T_2 = 60\text{lb.}$$

To get the tension in the upper segment, we use the equation for the upper boy to be in equilibrium,

$$\sum F_y = 0: T_1 - T_2 - W_0 = 0$$

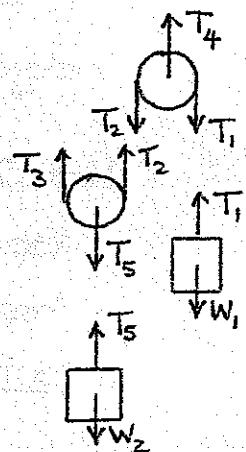
$$T_1 = T_2 + W_0 = (60 + 90)\text{lb} = 150\text{lb.}$$

8-7) We have a significant simplification because the pulleys are frictionless and weightless.

Last note on ropes: A frictionless pulley does not break a rope into two segments, so the tension is the same on either side of the pulley. This is the only exception to Note 1 above.

In this problem, we have $T_1 = T_2 = T_3$.

We draw a free-body diagram for each weight or pulley. (Note that, as stated in 8-5, we don't really need a free-body diagram for a rope.)



In static equilibrium each object must obey $\sum F_y = 0$.

weight 1: $T_1 - W_1 = 0 \Rightarrow T_1 = T_2 = T_3 = 300\text{N}$.

weight 2: $T_5 - W_2 = 0 \Rightarrow T_5 = W_2$.

left pulley: $T_2 + T_3 - T_5 = 0 \Rightarrow T_5 = T_2 + T_3$

or $W_2 = 600\text{ N}$.

right pulley: $T_4 - T_1 - T_2 = 0 \Rightarrow T_4 = 600\text{N}$.

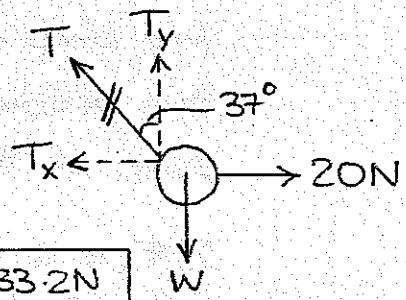
8-13) The string's tension, T , must balance the 20N force and the weight, w .

Its components are

$$T_x = -T \sin 37^\circ, T_y = T \cos 37^\circ.$$

$$\sum F_x = 0 \Rightarrow 20\text{N} - T \sin 37^\circ = 0 \text{ or } T = 33.2\text{N}$$

$$\sum F_y = 0 \Rightarrow T \cos 37^\circ - w = 0 \text{ or } w = 26.5\text{N}$$



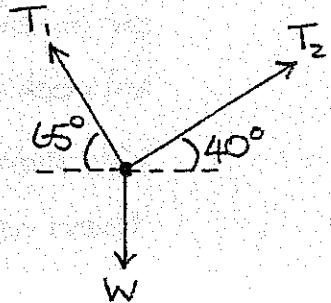
8-15) Draw the free-body diagram for the knot where the cords meet.

(We know the weight of the object acts downwards on the knot because the vertical string just transmits the force of gravity from the object to the knot.)

$$\sum F_x = 0 \Rightarrow T_2 \cos 40^\circ - T_1 \cos 65^\circ = 0 \text{ or } T_2 = \frac{\cos 65^\circ}{\cos 40^\circ} T_1$$

$$\sum F_y = 0 \Rightarrow T_2 \sin 40^\circ + T_1 \sin 65^\circ - w = 0$$

Substitute for $T_2 \Rightarrow T_1 = \frac{w}{\sin 65^\circ + \frac{\cos 65^\circ \times \sin 40^\circ}{\cos 40^\circ}} = 39.7\text{N}$.

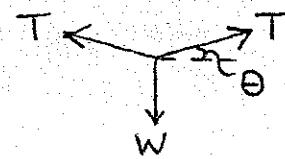
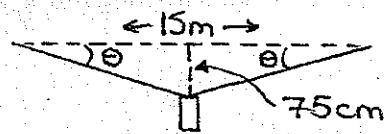


$$T_2 = \frac{\cos 65^\circ}{\cos 40^\circ} T_1 = 21.9\text{N.}$$

8-17) It is important to get the geometry correct: 15m is the horizontal distance between the poles, not the length of cable.

Angle between cable and horizontal,

$$\theta = \text{inv} \tan\left(\frac{0.75m}{7.5m}\right) = 5.7^\circ.$$



Now consider the free-body diagram for the point where the lamp hangs off the cable. Due to the symmetry of the problem, the tension T , is the same on each side of the suspension point.

$$\sum F_y = 0 \Rightarrow T \sin \theta + T \sin \theta - W = 0$$

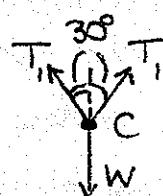
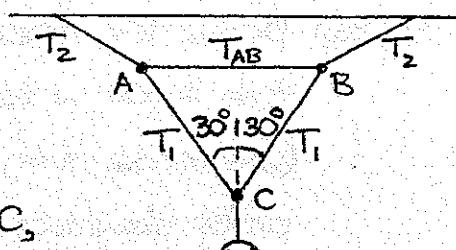
$$T = \frac{W}{2 \sin \theta} = \frac{800N}{2 \sin 5.7^\circ} = 4030N.$$

8-19) Again, symmetry simplifies the problem, so we need only introduce 3 unknown tensions.

We obtain T_1 by considering point C, then use this at point A to get T_{AB} .

$$\text{At } C, \sum F_y = 0 \Rightarrow 2T_1 \cos 30^\circ - W = 0$$

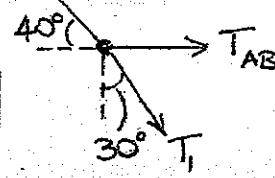
$$T_1 = \frac{W}{2 \cos 30^\circ} = 28.9N.$$



$$\text{At } A, \sum F_x = 0 \Rightarrow T_{AB} + T_1 \sin 30^\circ - T_2 \cos 40^\circ = 0$$

$$\sum F_y = 0 \Rightarrow T_2 \sin 40^\circ - T_1 \cos 30^\circ = 0$$

These give $T_2 = 38.9N$ and $T_{AB} = 15.4N$.



Since $\frac{1}{2}kx_{\max}^2 = \frac{1}{2}kx^2 + \frac{1}{2}mv^2$, maximum velocity is obtained at $x=0$:

$$\frac{1}{2}mv_{\max}^2 = \frac{1}{2}kx_{\max}^2$$

$$v_{\max} = \sqrt{\frac{k}{m}} x_{\max} = \sqrt{\frac{0.269 \text{ N/m}}{0.03 \text{ kg}}} (0.1 \text{ m}) = 0.3 \text{ m/s.}$$

Since $a = \frac{kx}{m}$, maximum acceleration is obtained at $x = x_{\max}$:

$$a_{\max} = \frac{kx_{\max}}{m} = \frac{(0.269 \text{ N/m})(0.1 \text{ m})}{0.03 \text{ kg}} = 0.90 \text{ m/s}^2.$$

NB: $x_{\max} = 10 \text{ cm}$ because oscillation is between $x = +x_{\max}$ and $x = -x_{\max}$ (a distance of 20 cm).

16-25) The period of a simple pendulum is

$$T = 2\pi \sqrt{\frac{L}{g}} = 2\pi \sqrt{\frac{2.0 \text{ m}}{9.81 \text{ m/s}^2}} = 7.0 \text{ s.}$$

16-29) The washer will not fall as fast as the piston if the piston's downward acceleration exceeds the acceleration due to gravity, g .

The critical condition is

$$a_{\max} = \frac{kx_{\max}}{m} = g$$

where m is the mass of the piston (not the washer).

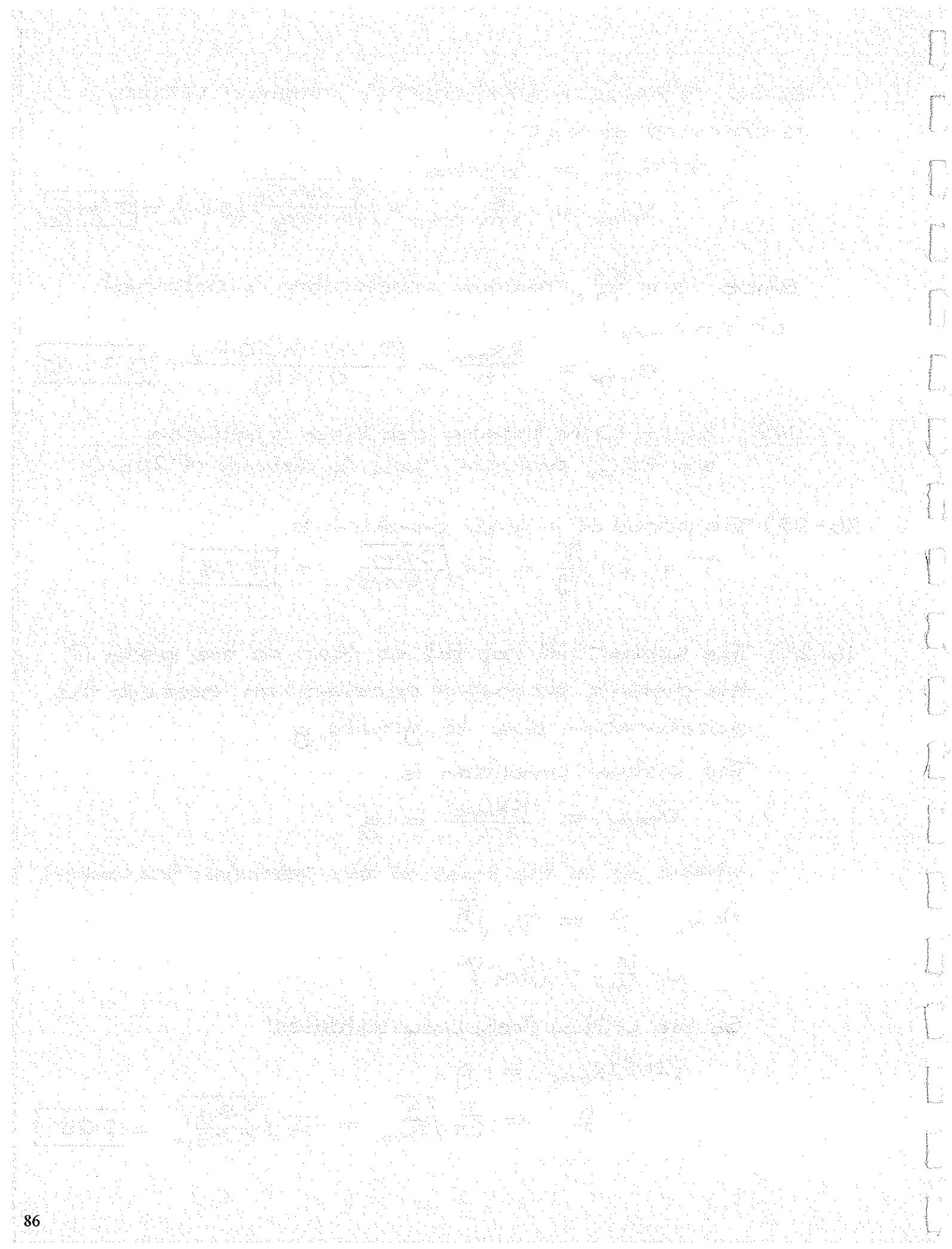
$$\text{Now, } f = \frac{1}{2\pi} \sqrt{\frac{k}{m}}$$

$$\Rightarrow \frac{k}{m} = (2\pi f)^2$$

So the critical frequency satisfies

$$(2\pi f)^2 x_{\max} = g$$

$$f = \frac{1}{2\pi} \sqrt{\frac{g}{x_{\max}}} = \frac{1}{2\pi} \sqrt{\frac{9.8 \text{ m/s}^2}{0.05 \text{ m}}} = 2.2 \text{ s}^{-1}$$



Chapter 17 (2, 3, 6, 8, 12, 16, 22, 23, 24)

17-2) The wavelength, frequency and speed of a wave are connected by the equation

$$\lambda f = v$$

$$f = \frac{v}{\lambda} = \frac{3 \times 10^8 \text{ m/s}}{633 \times 10^{-9} \text{ m}} = 4.7 \times 10^{14} \text{ Hz.}$$

17-3) Again using $\lambda f = v$

$$\lambda = \frac{v}{f} = \frac{3 \times 10^8 \text{ m/s}}{1020 \times 10^3 \text{ Hz}} = 294 \text{ m.}$$

17-6) (a) By inspection of figure,

wavelength = repeat distance of wave = 4 cm.

(b) Again by inspection,

amplitude = max. deviation from average = 0.1 mm.

(c) Period, $T = \frac{1}{f} = \frac{1}{200 \text{ Hz}} = 0.005 \text{ s.}$

(d) Speed, $v = \lambda f = (0.04 \text{ m})(200 \text{ Hz}) = 8 \text{ m/s.}$

17-8)(a) When a string of length L vibrates in one segment,

$$\lambda = 2L = 2(0.4 \text{ m}) = 0.8 \text{ m.}$$

(b) $v = \lambda f = (0.8 \text{ m})(300 \text{ Hz}) = 240 \text{ m/s.}$

17-12)(a) At the fundamental frequency

$$\lambda = 2L = 2(14 \text{ m}) = 28 \text{ m.}$$

(b) $v = \lambda f = (28 \text{ m})(170 \text{ Hz}) = 4760 \text{ m/s.}$

(c) Resonant frequencies are

$$f_n = \frac{V}{\lambda_n} = \frac{V}{2L/n} = n f_1, \quad n=1, 2, 3, \dots$$

Three lowest frequencies after fundamental, f_1 ,
are $f_2, f_3, f_4 = [340, 510, 680 \text{ Hz.}]$

17-16) Velocity of compressive wave,

$$V = \frac{\text{distance travelled}}{\text{time}} = \frac{2 \times 6.0 \text{ m}}{2.1 \text{ s}} = 5.7 \text{ m/s.}$$

Frequencies of compressive waves satisfy

$$f_n = n \left(\frac{V}{2L} \right) = n \left(\frac{5.7 \text{ m/s}}{2 \times 6.0 \text{ m}} \right) = n (0.48 \text{ Hz}), \quad n=1, 2, 3, \dots$$

Lowest 3 frequencies = $[0.48, 0.95, 1.43 \text{ Hz.}]$

17-22) For sound in a tube closed at both ends

$$f_n = n \left(\frac{V}{2L} \right) = n \left(\frac{340 \text{ m/s}}{2 \times 3 \text{ m}} \right) = n (56.7 \text{ Hz}), \quad n=1, 2, 3, \dots$$

Lowest 4 frequencies = $[56.7, 113.3, 170, 226.7 \text{ Hz.}]$

17-23) For sound in a tube closed at one end

$$f_n = (2n-1) \left(\frac{V}{4L} \right) = (2n-1) \left(\frac{340 \text{ m/s}}{4 \times 2 \text{ m}} \right) = (2n-1) (42.5 \text{ Hz}), \quad n=1, 2, 3, \dots$$

Lowest 4 frequencies = $[42.5, 127.5, 212.5, 297.5 \text{ Hz.}]$

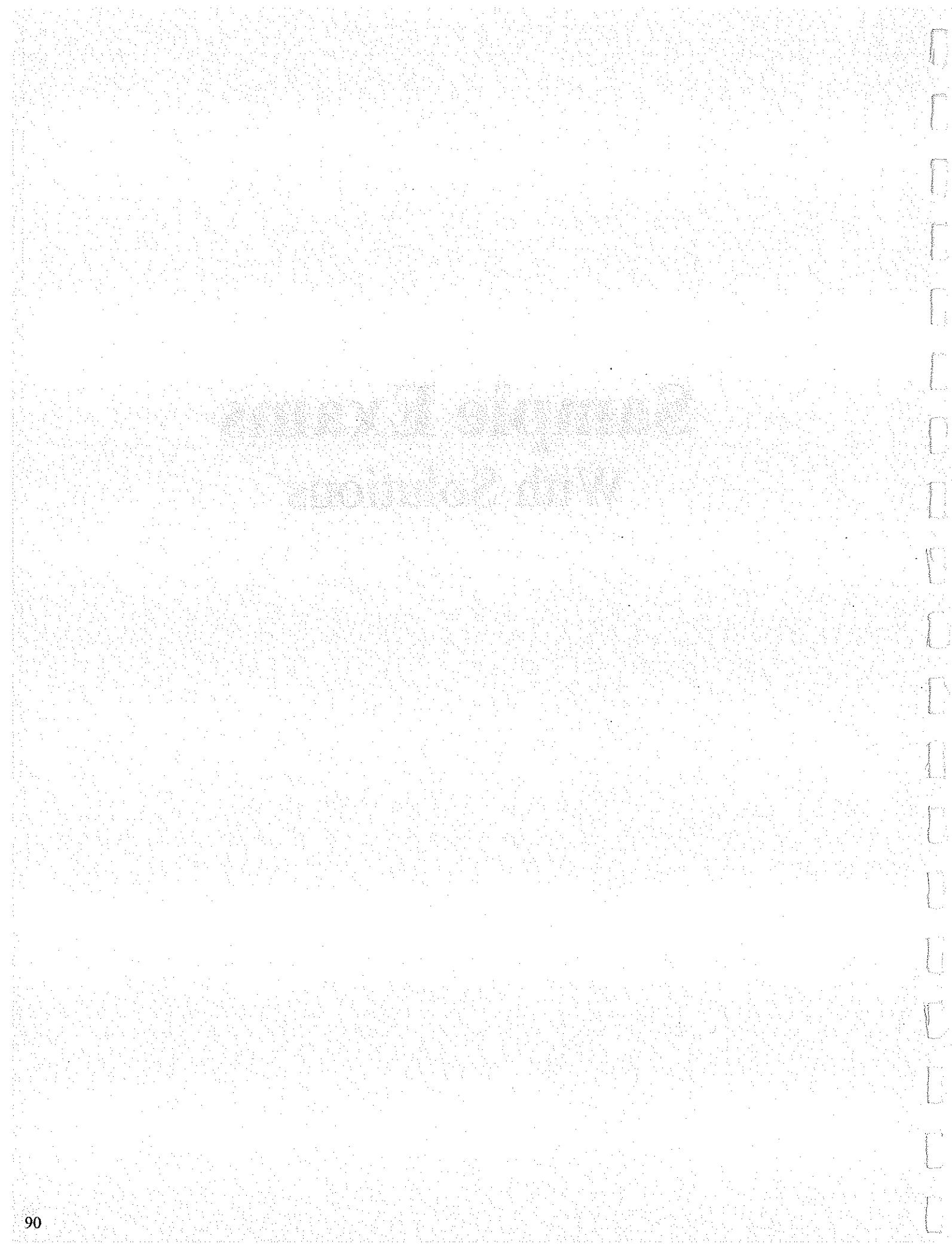
17-24) For sound in a tube open at both ends,

$$f_n = n \left(\frac{V}{2L} \right) = n \left(\frac{340 \text{ m/s}}{2 \times 5 \text{ m}} \right) = n (34 \text{ Hz}), \quad n=1, 2, 3, \dots$$

Lowest 4 frequencies = $[34, 68, 102, 136 \text{ Hz.}]$

Sample Exams

With Solutions



Name (print, last first): _____ Signature: _____

On my honor, I have neither given nor received unauthorized aid on this examination.

YOUR TEST NUMBER IS THE 5-DIGIT NUMBER AT THE TOP OF EACH PAGE.

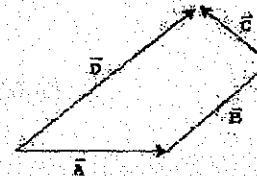
DIRECTIONS

- (1) Code your test number on your answer sheet (use 76-80 for the 5-digit number). Code your name on your answer sheet. DARKEN CIRCLES COMPLETELY. Code your student number on your answer sheet.
- (2) Print your name on this sheet and sign it also.
- (3) Do all scratch work anywhere on this exam that you like. At the end of the test, this exam printout is to be turned in. No credit will be given without both answer sheet and printout with scratch work most questions demand.
- (4) Blacken the circle of your intended answer completely, using a #2 pencil or blue or black ink. Do not make any stray marks or the answer sheet may not read properly.
- (5) The answers are rounded off. Choose the closest to exact. There is no penalty for guessing.

>>>>>WHEN YOU FINISH <<<<<<

Hand in the answer sheet separately.

1. Which of the following equations is correct?

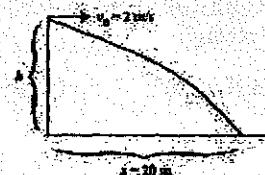


- (1) $\vec{A} + \vec{B} = \vec{D} - \vec{C}$ (2) $\vec{A} = \vec{B} + \vec{D}$ (3) $\vec{B} = \vec{A} + \vec{C} - \vec{D}$ (4) $\vec{C} = \vec{A} + \vec{B} + \vec{D}$ (5) $\vec{A} - \vec{B} = \vec{C} + \vec{D}$

2. An airplane is flying straight east with a velocity of 300 km/h relative to the surrounding air. But the air itself is moving southwest (that is, 45° south of west) relative to the earth with a velocity of 100 km/h due to a strong wind. What is the speed of the plane relative to the earth in km/h?

- (1) 240 (2) 380 (3) 200 (4) 300 (5) 100

3. A ball is thrown at 2 m/s horizontally. It lands 20 m away from starting point. What is h (in m)?



- (1) 490.0 (2) 75 (3) 3 (4) 56.3 (5) 408

4. No matter how powerful a car's motor, it can accelerate no faster than the friction force between pavement and wheels allows. For this reason, a typical car's maximum acceleration is about 8 m/s^2 . What is the shortest time a car would require to accelerate from rest to a speed of 30 m/s?

- (1) 3.75 s (2) 56.3 s (3) 2.74 s (4) 8.00 s (5) 0.267 s

5. A car moving at 90 km/hr collides into a row of bushes. It moves 10 m before it completely stops. Suppose its mass is equal to 2000 kg. What is the average force which acted on the car? (in N)

(1) -6.2×10^4 N (2) 4300 N (3) 3.7×10^5 N (4) -3.7×10^5 N (5) no force

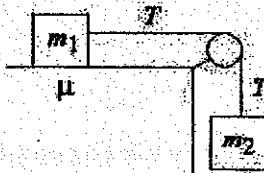
6. For the situation shown, M_1 is 500 g and M_2 is 600 g. How large must the tension P in the upper cord be to move the mass upward at a constant speed of 2.0 m/s?

(1) 10.8 N
 (2) 1100 N
 (3) 100 N
 (4) 4.9 N
 (5) 13.0 N



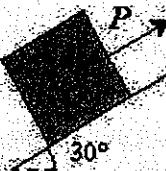
7. Given $m_1 = 12$ kg, $m_2 = 20$ kg, and $a = 5$ m/s, find the coefficient of friction.

(1) 0.31 (2) 0.52 (3) 2.6 (4) 0.42 (5) 0.26



8. Refer to figure. How large is P if the box moves up the incline at constant speed? The box has a mass of 5.0 kg and $\mu_k = 0.40$.

(1) 41.5 N (2) 7.4 N (3) 66.8 N (4) 18.0 N (5) 19.5 N

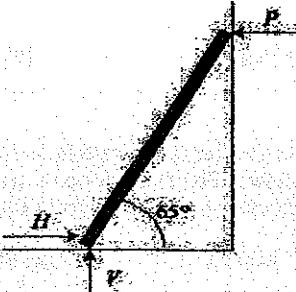


9. A ring remains at rest with three strings pulling on it. One string pulls with a force of 25 N at an angle of 90° . The other pulls with a force of 70 N at an angle of 270° . What is the magnitude and direction of the force caused by the third string?

(1) 45 N at 90° (2) 45 N at 180° (3) 45 N at 0° (4) 95 N at 90° (5) 95 N at 270°

10. A uniform ladder that weighs 200 N leans against a smooth wall as shown. At a smooth surface such as the wall, the surface exerts a force P on the ladder which is directed perpendicular to the wall. How large must the horizontal force H on the foot of the ladder be if the ladder is not to slip?

(1) 46.6 N (2) 215 N (3) 200 N (4) 65 N (5) 93.5 N



Spring 2003 Exam #1

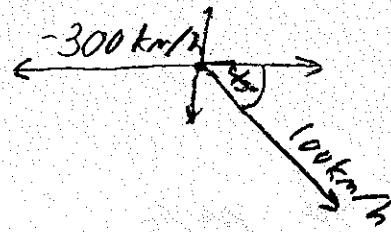
- 1) For subtraction just reverse the direction of the vector so choice one

$$\vec{A} + \vec{B} = \vec{D} - \vec{C}$$

is equal to

$\vec{A} + \vec{B} = \vec{D} + (-\vec{C})$ where \vec{C} is now reversed. By head to tail method this is true.

- 2) Add the two velocities first in components



$$V_x = -300 + \cos 45^\circ (100)$$

$$V_x = -229 \text{ km/h}$$

$$V_y = -\sin 45^\circ (100)$$

$$V_y = -71 \text{ km/h}$$

now find magnitude of velocity

$$V = \sqrt{V_x^2 + V_y^2} = 240 \text{ km/h}$$

- 3) since x and y motion are independent of each other first look at x

$$x = 2t$$

$$20 = 2t$$

$$t = 10$$

now looking at y with our time from above

$$0 = y(t_0) = h - 4.9t^2 = 0$$

↑
ground

$$4.9t^2 = h$$

$$\underline{490 \text{ m} = }$$

4)

$$V_{\text{initial}} = 0 \text{ m/s} \quad V_{\text{final}} = 30 \text{ m/s}$$

$$a = 8 \text{ m/s}^2$$

$$v(t) = at$$

$$30 = 8t$$

$$t = \frac{30}{8} = \frac{15}{4} = \underline{3.75 \text{ s}}$$

5) first resolve km/hr to m/s

$$\frac{90 \text{ km}}{1 \text{ hr}} \left| \frac{1000 \text{ m}}{1 \text{ km}} \right| \frac{1 \text{ hr}}{3600 \text{ s}} = 25 \text{ m/s}$$

$$\text{so } V_{\text{initial}} = 25 \text{ m/s} \quad V_{\text{final}} = 0 \text{ m/s}$$

$$X_{\text{initial}} = 0 \text{ m} \quad X_{\text{final}} = 10 \text{ m}$$

now we look for a

$$V_f^2 = V_i^2 + 2a(x_{\text{final}} - x_{\text{initial}})$$

$$0 = 25^2 + 2a(10)$$

$$a = -\frac{25^2}{20} = -31.25 \text{ m/s}^2$$

Finally we can calculate the force

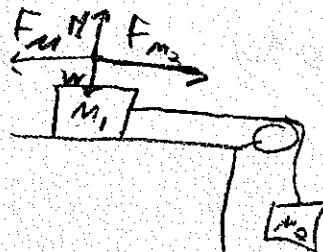
$$F = ma = 2000(-31.25) = \underline{-6.25 \times 10^4 N}$$

b) total mass = $500g + 600g = 1100g = 1.1kg$

Since the masses are not accelerating
the force needed is the force to overcome
gravity.

$$F = mg = 1.1(9.8) = \underline{10.78N} = \text{Tension}$$

7)



$$F_{m_2} = M_{m_2}g = 20kg(9.8m/s^2) = 196N$$

$$F_M = -M_k(M_{m_1}g) = -M_k(9.8(12)) = -117.6M_k N$$

$$F_{\text{total}} = ma = 32(5) = 160$$

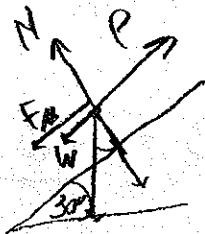
$$F_{\text{total}} = F_M + F_{m_2}$$

$$160 = 196 - 117.6M_k N$$

$$-36 = -117.6M_k$$

$$\underline{M_k = .31}$$

8)



$W = \text{weight} = mg$
in order for the object to move at a constant speed the net force or it must be zero

$N = W \cos 30^\circ$ so the vertical forces on the box cancel

$$P = W \sin 30^\circ + W \cos 30^\circ (\mu_k)$$

$$P = 5(9.8)[\sin 30^\circ + \mu_k \cos 30^\circ]$$

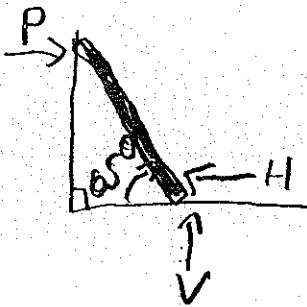
$$\underline{P = 41.5 N}$$

9) For the ring to remain at rest there can be no net force acting on it.
to find the third force first find the net force from the other two



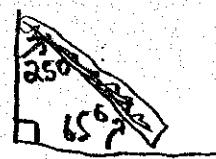
So in order to balance the net force of 45N downward (270°) we need 45N upward (90°)

10)



Systems at equilibrium hence $H = P$

so first



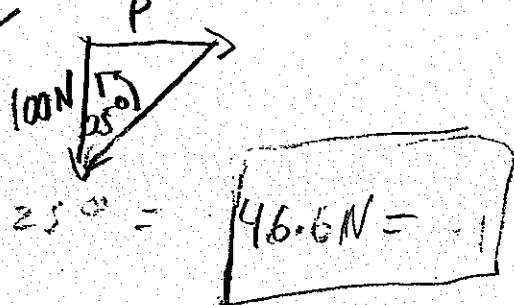
since all angles in
a triangle must equal
 180°

then realize that the force of the ladder when
it leans against the wall is really $\frac{W}{2} = 100N$,

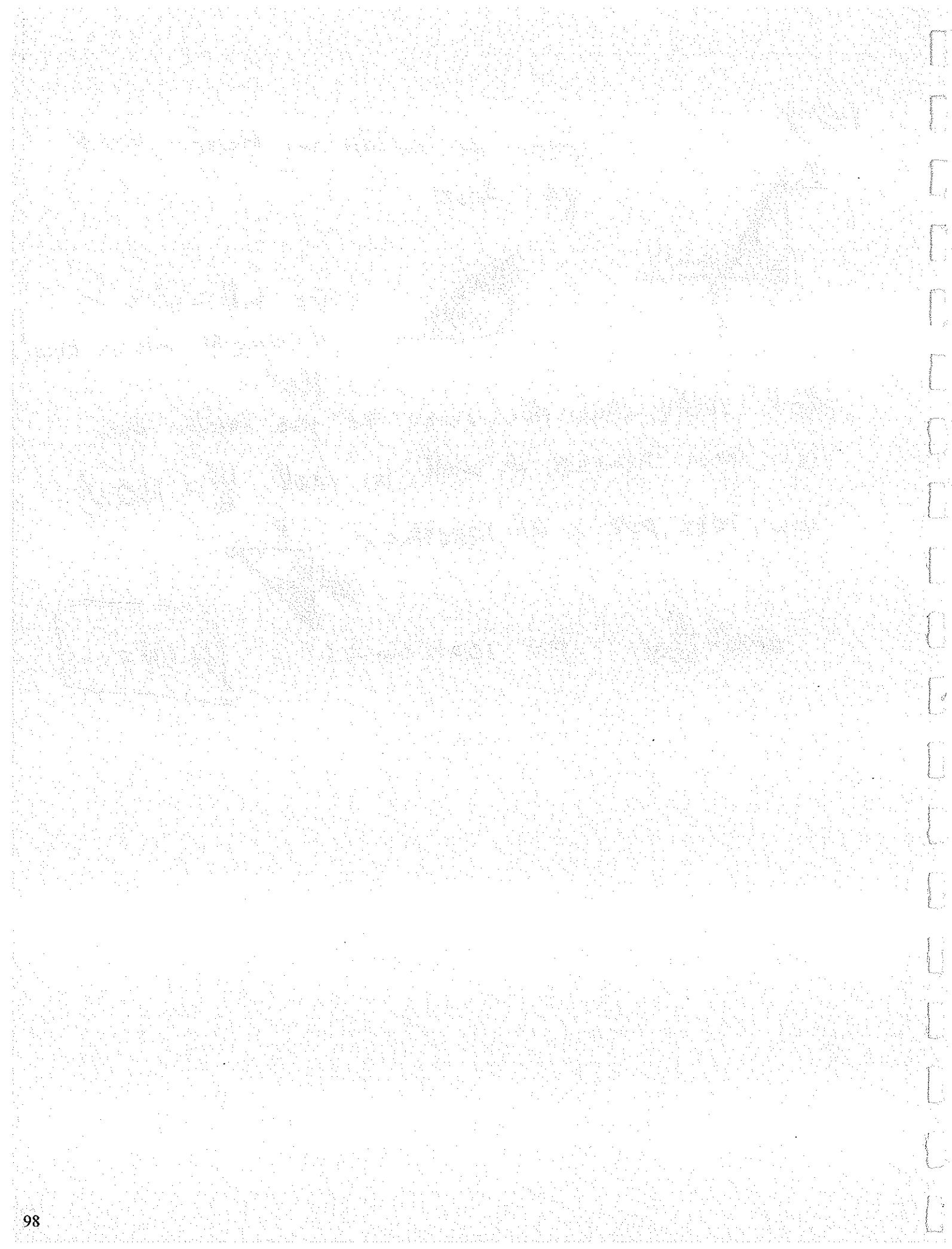
Now lets put it all together,

$$\tan 25^\circ = \frac{P}{100N}$$

$$P = 100N \cdot \tan 25^\circ =$$



$$46.6N =$$



Name (print): _____ Signature: _____

*On my honor, I have neither given nor received unauthorized aid on this examination.***R TEST NUMBER IS THE 5-DIGIT NUMBER AT THE TOP OF EACH PAGE****DIRECTIONS**

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- (6) Good luck!!!

>>>>> WHEN YOU FINISH <<<<<

Hand in the green answer sheet separately.

Formulas

$$g = 9.8 \text{ m/s}^2 = 32 \text{ ft/s}^2 \quad 1 \text{ mile} = 5280 \text{ ft} = 1.61 \text{ km}$$

$$G = 6.67 \times 10^{-11} \frac{\text{Nm}^2}{\text{kg}^2}$$

$$\text{mass of earth} = 6.0 \times 10^{24} \text{ kg}$$

$$\text{radius of earth} = 6.4 \times 10^3 \text{ km}$$

1. A vector V which makes an angle of +27 degrees with the x-axis and has an x-component $V_x = 25$ m. What is the magnitude (length) of V in m?
- (1) 28.1 (2) 22.3 (3) 55.1 (4) 11.3 (5) 25.0
2. The water in a wide river is flowing with a velocity of 7.0 knots/hr parallel to the river banks. (See Figure 1.) A boat starts to cross the river with a velocity of 18.0 knots/hr with his bow pointed directly to the other side of the river (perpendicular to the river). What is the magnitude of the net velocity of the boat (in knots/hr) with respect to someone standing on the riverbank?
- (1) 19.3 (2) 25.0 (3) 18.0 (4) 34.8 (5) 0.0
3. From atop the Century Tower (100 ft tall), you throw a ball downward with an initial velocity (downward) of 20 ft/s. How long does it take (in seconds) to reach the bottom?
- (1) 1.95 (2) 2.91 (3) 6.5 (4) 3.2 (5) 18.3

4. On the distant planet Xorcon, Spaceman Spiff throws an object into the air from the surface with an initial upward velocity of 20 m/s. It returns to the surface 29 s later. What is the value of the acceleration due to gravity (in m/s^2) on Xorcon (i.e., g_{Xorcon})?
- (1) 1.4 (2) 9.8 (3) 26.5 (4) 4.3 (5) 5.8
5. A block is sitting at rest on an inclined plane that makes an angle θ with respect to the horizontal. If the static coefficient of friction (μ_s) is 0.56, what is the value of θ (in degrees) for which the block will start to move? (You do not need to know the mass of the block to do the problem.)
- (1) 29.2 (2) 12.3 (3) 46.9 (4) 36.0 (5) 90.0
6. Two small neutron stars each having a mass of 4×10^{31} kg are separated by a distance of 1000 km. What is the magnitude of the gravitation force of attraction (in N) between them?
- (1) 1.1×10^{41} (2) 1.1×10^{47} (3) 6.2×10^{41} (4) 4.3×10^{40} (5) 8.2×10^5
-

7. A box weighing 50 N is pushed up a ramp making an angle of 25 degrees with the horizontal by a 60 N force acting parallel to the ramp. (See Figure 2) The coefficient of kinetic friction between the box and the ramp is 0.25. What is the net acceleration on the box (in m/s^2)?

- (1) 5.4 (2) 24.7 (3) 2.9 (4) 1.4 (5) 10.4

8. For the mobile shown in Figure 3, what must the mass M_2 be (in kg) if the mobile is balanced? Assume the connecting rods are massless.

- (1) 0.67 (2) 0.33 (3) 2.0 (4) 1.0 (5) 0.5

9. A frictionless pulley (see Figure 4) has two masses, $m_1 = 2.5 \text{ kg}$ and mass $m_2 = 2.0 \text{ kg}$, hanging from it. If the masses are released from rest, what is the tension (in N) in the cord?

- (1) 21.8 (2) 1.1 (3) 24.5 (4) 4.5 (5) 7.9

10. How much horizontal force (in N) is needed to pull a 12.0 N pendulum ball aside until the ball makes an angle of 25 degrees with respect to the vertical as shown in Figure 5?

- (1) 5.6 (2) 12.3 (3) 46.9 (4) 36.0 (5) 90.0

11. A student in downtown Gainesville walks 10.0 blocks south then turns to the east and walks 8.0 blocks then finally turns to the northwest and walks 2.83 blocks. What is the magnitude (in blocks) of the student's displacement vector?

- (1) 10 (2) 5 (3) 8.8 (4) 14.1 (5) 12.8

12. Vector A has magnitude 10 and makes an angle of 30° with respect to the x-axis. Vector B has magnitude 8 and makes an angle of -60° with respect to the x-axis. What angle does the vector $C = A - B$ make with respect to the x-axis?

- (1) 69 (2) 21 (3) 81 (4) -81 (5) -9
-

13. When the space shuttle lands at Kennedy Space Center, it goes from 200 mph to rest in 1 mile of runway. What is the MAGNITUDE of its deceleration in terms of g , the acceleration of gravity?

- (1) 0.25 (2) 8.1 (3) 621 (4) 3.0 (5) 20,000

14. A ball is thrown upward (on Earth) so it reaches a maximum height of 20 ft. How long in seconds does it take to reach that height?

- (1) 1.11 (2) 1.24 (3) 0.79 (4) 0.62 (5) 0.5

15. The mass of Planet X is twice the mass of the Earth and its radius is $1/2$ the radius of earth. How many pounds will a child who weighs 100 lbs on Earth weigh on Planet X?

- (1) 800 (2) 100 (3) 400 (4) 25 (5) 12.5

16. A block is attached to a rope and hangs inside an elevator car as shown in figure 6. The tension in the rope is 30 N and the car is accelerating DOWNWARD at 3.0 m/s^2 . What is the mass of the block in kg?

- (1) 4.4 (2) 3.1 (3) 2.3 (4) 43 (5) 23

17. The coefficient of kinetic friction between a 2000 kg car that is skidding on an icy road is 0.1. If the car is initially going 50 km/hr, then how long in seconds, will it take to come to a complete stop?

- (1) 14.2 (2) 5.1 (3) 1.4 (4) 51 (5) 18.3

18. A 50 kg box sitting on the level floor is being pulled with a force of 100 N by a rope that is inclined 40° above the horizontal. What is the magnitude of the normal force in N?

- (1) 426 (2) 490 (3) 413 (4) 567 (5) 554
-

19. In figure 7, how far from ball A (in m) must one place the pivot in order to balance this device? Assume that the connecting rod has negligible weight.

- (1) 1.67 (2) 0.83 (3) 1.25 (4) 2.0 (5) 1.5

20. For the lever system shown in figure 8, what must be the value of the weight, W (in N) for the system to be balanced? Assume that the rod is uniform and has a mass of 0.5 kg.

- (1) 34.9 (2) 30 (3) 44.7 (4) 14.9 (5) 45

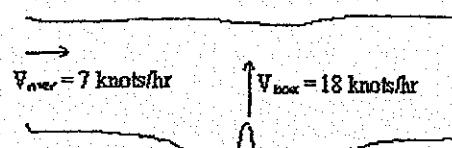


Figure 1

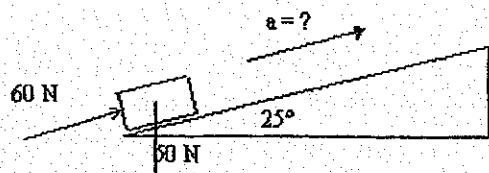


Figure 2

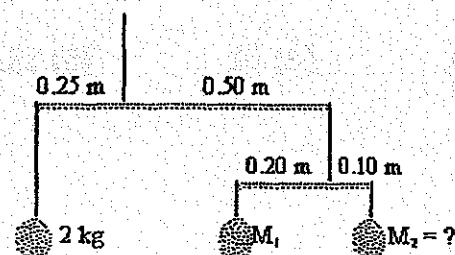


Figure 3

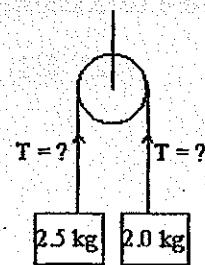


Figure 4

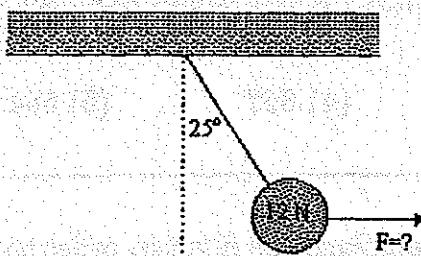
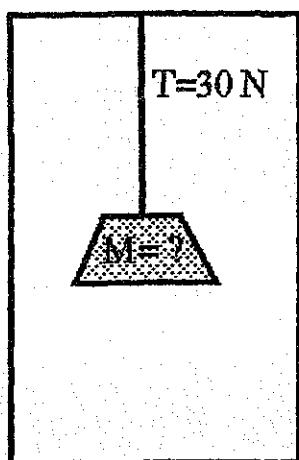


Figure 6



$$a = 3 \text{ m/s}^2$$

Figure 7

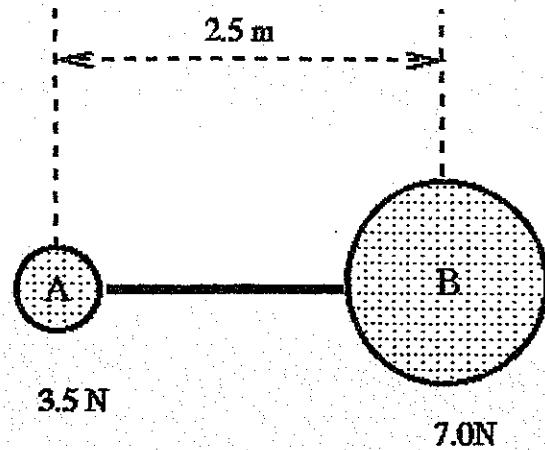
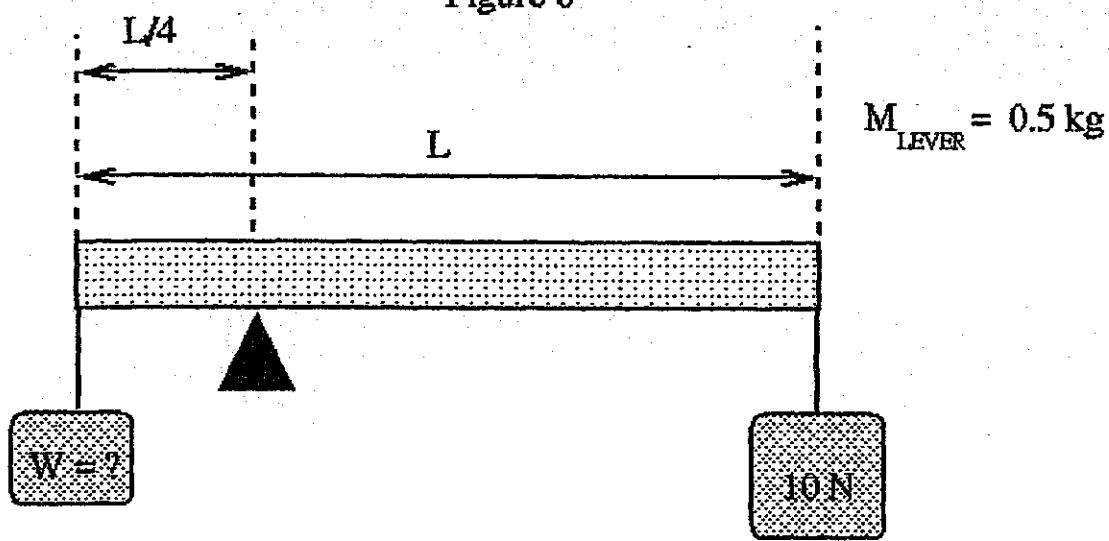
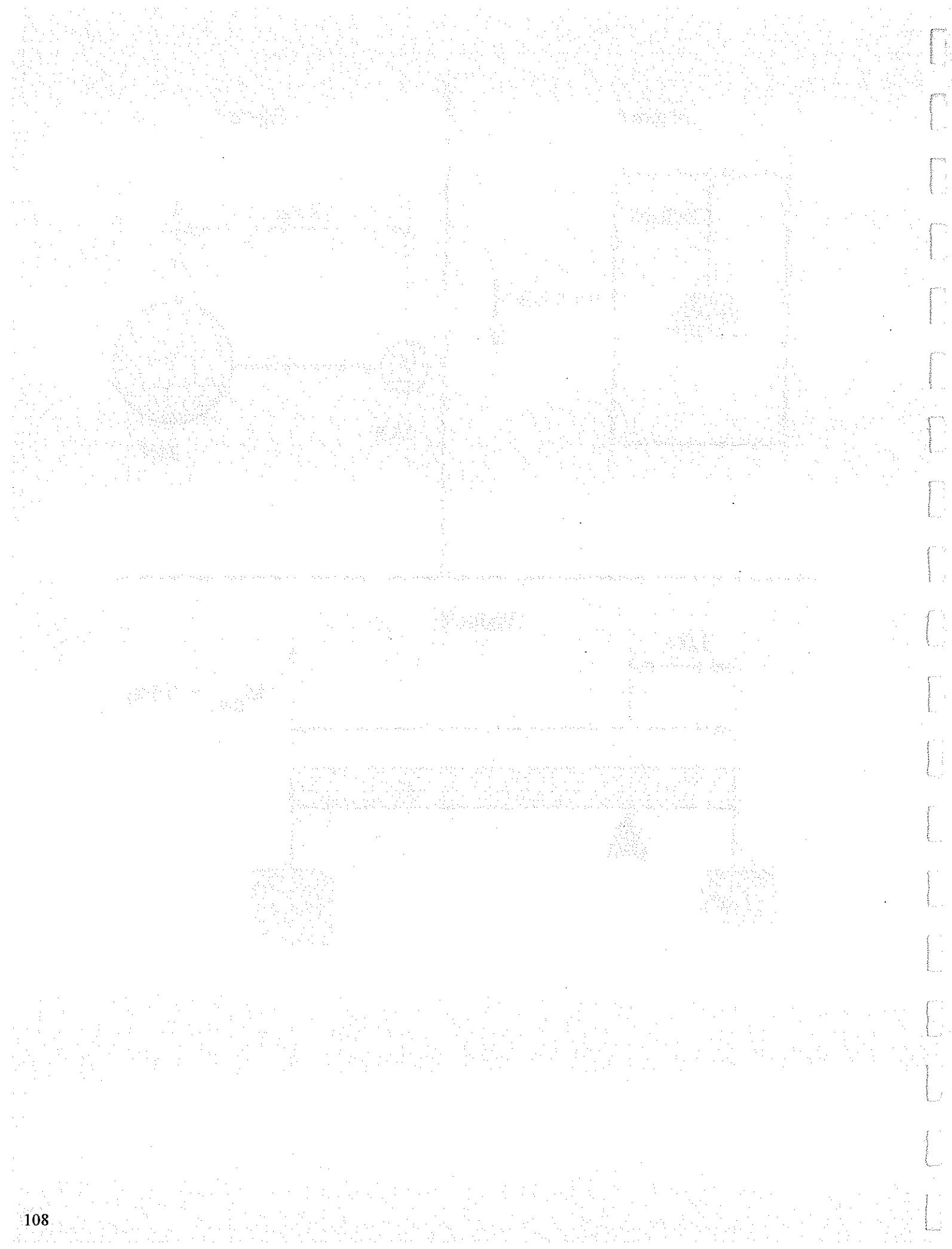


Figure 8



$$M_{\text{LEVER}} = 0.5 \text{ kg}$$

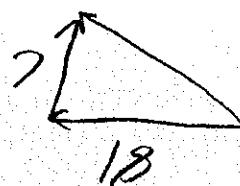


1997 Exam 2

1) $\text{length} \cdot \cos 27^\circ = 25$

length = 28.1 m

2) the two velocities add



$$|v| = \sqrt{7^2 + 18^2}$$

$$|v| = \underline{19.3 \text{ m}}$$

3)

$$x = x_0 + v_{x_0} t + \frac{1}{2} a t^2$$

$$0 = 100 - 20t - 16t^2$$

$$0 = 4t^2 + 5t - 20$$

$$t = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

4)

$$v_0 = 20 \text{ m/s}$$

$$x(t) = v_0 t + \frac{1}{2} a t^2$$

$$t = 29 \text{ s}$$

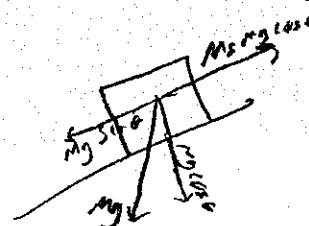
$$0 = 20(29) + a / \frac{1}{2}(29)^2$$

$$x(29) = 0$$

$$a = \underline{-1.4 \text{ m/s}^2}$$

5)

$$\mu_s = 1.56$$



$$mg \sin \theta = \mu_s mg \cos \theta$$

$$\tan \theta = \frac{\sin \theta}{\cos \theta} = \mu_s = 1.56$$

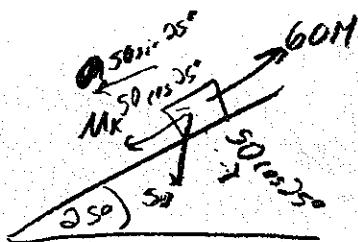
$$\theta = 29.2^\circ$$

6)

$$F = \frac{G m_1 m_2}{r^2} = \frac{(6.67 \times 10^{-11} N \frac{m^2}{kg^2})(4 \times 10^3 kg)^2}{(10000 \times 10^3 m)^2}$$

$$= 1.1 \times 10^{-4} N$$

7)



$$mg = 50 N$$

$$m = \frac{50}{9.8} kg$$

$$F = ma$$

$$60 - .25(50) \cos 25^\circ - 50 \sin 25^\circ = \left(\frac{50}{9.8} kg\right) a$$

$$a = 5.4 m/s^2$$

8)

$$2M_1 = .1(M_2) \quad <\text{balance Torque on right hand side}$$

$$M_1 = \frac{1}{2} M_2$$

$$2kg(.25m) = (M_1 + M_2)(.5m)$$

$$\frac{2kg(.25m)}{\frac{3}{2}(\frac{1}{2})} = M_2 = \frac{2}{3} kg = .67 kg$$

$$9) (2.5 \text{ kg} - 2.0 \text{ kg}) 9.8 \text{ m/s}^2 = F$$

$$F = 4.9 \text{ N}$$

$$F = m a$$

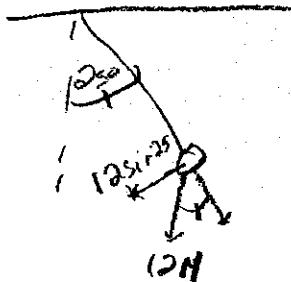
$$4.9 = (2.5 + 2.0) \text{ kg} / a$$

$$a = 1.089 \text{ m/s}^2$$

$$(2.5 \text{ kg})(9.8 \text{ m/s}^2) - T = (2.5 \text{ kg})(1.089)$$

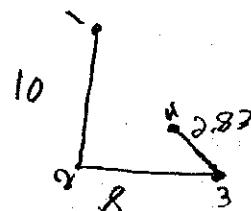
$$\underline{T = 21.2 \text{ N}}$$

10)



$$F = 12 \sin 25^\circ = 5.1 \text{ N}$$

11)



distance from 1 to 3 can be calculated with $a^2 + b^2 = c^2$

$$10^2 + 8^2 = c^2 \Rightarrow c = \sqrt{164}$$

now the first meter is in the opposite direction so subtract it

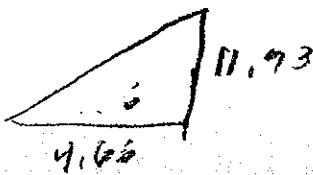
$$d = \sqrt{164} - 2.83 \approx 10$$

12) Break the vectors into components

$$A = 10 \cos 30^\circ \hat{i} + 10 \sin 30^\circ \hat{j}$$

$$B = 8 \cos -60^\circ \hat{i} + 8 \sin -60^\circ \hat{j}$$

$$\begin{aligned} C = A - B &= [10 \cos 30^\circ - 8 \cos -60^\circ] \hat{i} + [10 \sin 30^\circ - 8 \sin -60^\circ] \hat{j} \\ &= [8.66 - 4] \hat{i} + [5 + 6.93] \hat{j} \\ &= [4.66] \hat{i} + [11.93] \hat{j} \end{aligned}$$



$$\tan \theta = \frac{11.93}{4.66} = 2.56$$

$$\underline{\theta \approx 69^\circ}$$

13

$$V_F^2 = V_0^2 + 2ad$$

$$0 = (200 \text{ mi/hr})^2 + 2(1 \text{ mi})a$$

$$a = -20,000 \text{ mi/hr}^2$$

$$\frac{-20,000 \text{ mi}}{\text{hr}^2} \left| \frac{(1 \text{ hr})^2}{(3600 \text{ s})^2} \right| \frac{5580 \text{ ft}}{1 \text{ mi}} = 8,148 \text{ ft/sec}^2$$

$$\frac{8,148 \text{ ft/sec}^2}{32 \text{ ft/sec}^2} = .254 g$$

$$14) \begin{cases} 20m = v_{\max} - \frac{1}{2}(32 \text{ m/s}^2)t_{\max} \\ 0 = v_0 - 32t_{\max} \end{cases}$$

$$v_0 = 32t_{\max}$$

$$20m = 32t_{\max}^2 - 16t_{\max}^2$$

$$\frac{20}{16} = t_{\max}^2 \quad t_{\max} = \underline{1.118 \text{ s}}$$

$$15) F = G \frac{m_1 m_2}{r^2}$$

Now half the radius and double mass of lot per mass.

$$F = G \frac{2m_1 m_2}{(\frac{1}{2})^2 r^2} = 8G \frac{m_1 m_2}{r^2}$$

So the force and hence weight will be multiplied by 8.

$$W = 8 \cdot 100 \text{ lbs} = \underline{800 \text{ lbs}}$$

16) The block now feels no acceleration

$$a = (9.8 - 3) \text{ m/s}^2 = 6.8 \text{ m/s}^2$$

$$T = ma \Rightarrow 30 = m(6.8)$$

$$m = \underline{4.4 \text{ kg}}$$

17)

$$F_{\text{friction}} = mg \mu_k = ma$$

$$g \mu_k = a$$

$$a = 9.8(1.1) = .98$$

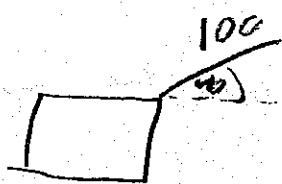
$$V_i = 50 \text{ km/hr} = 13.9 \text{ m/s}$$

$$V_f = V_i - at$$

$$0 = 13.9 - .98t$$

$$t = \underline{14.25}$$

18)



$$F_{\text{friction}} = \sin 40^\circ \cdot 100$$

$$N = mg - F_{\text{friction}}$$

$$N = 9.8(50) - \sin 40^\circ \cdot 100 = 425$$

19) here balance the torques

$$3.5x = 7(2.5-x)$$

$$10.5x = 17.5$$

$$x = \frac{17.5}{10.5} = 1.67$$

20) here again you must balance the torques
BUT the rod contributes

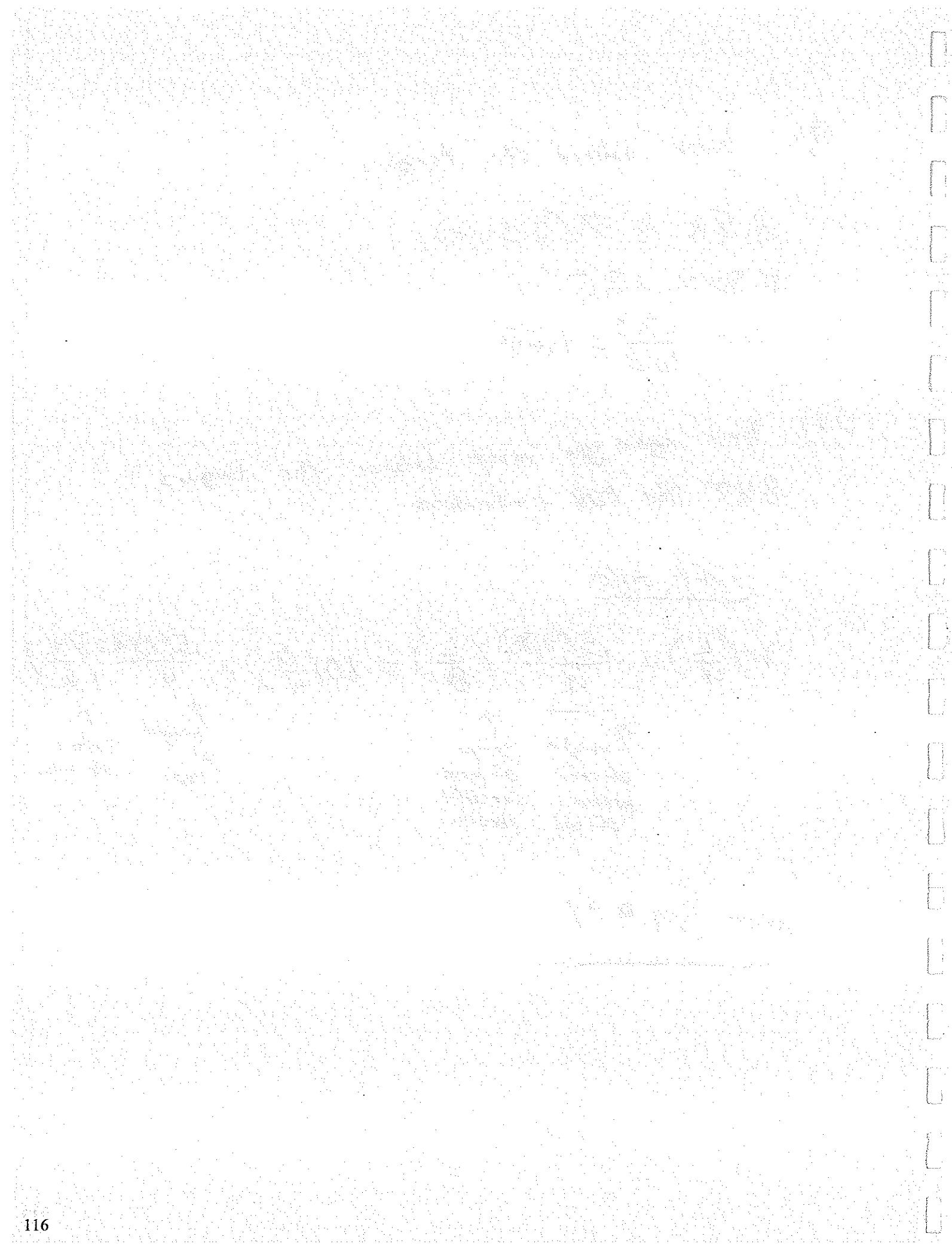
left side

$$W\left(\frac{L}{4}\right) + \frac{.5(1.8)}{4}\left(\frac{L}{8}\right) = 10\left(\frac{3L}{4}\right) + \frac{.5(3)(4.8)}{4}\left(\frac{3L}{2}\right)$$

↑ weight ↑
of left center
portion of mass
 for left
 portion

↑ weight ↑
of center
rod of mass

$$\underline{W = 34.9 \text{ N}}$$



PHYSICS DEPARTMENT

PHY 2004
D. Reitze, C. Stanton

Final Exam

December 15, 1997

Name (print): _____ Signature: _____

*On my honor, I have neither given nor received unauthorized aid on this examination.***YOUR TEST NUMBER IS THE 5-DIGIT NUMBER AT THE TOP OF EACH PAGE.****DIRECTIONS**

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>>>>>WHEN YOU FINISH <<<<<<

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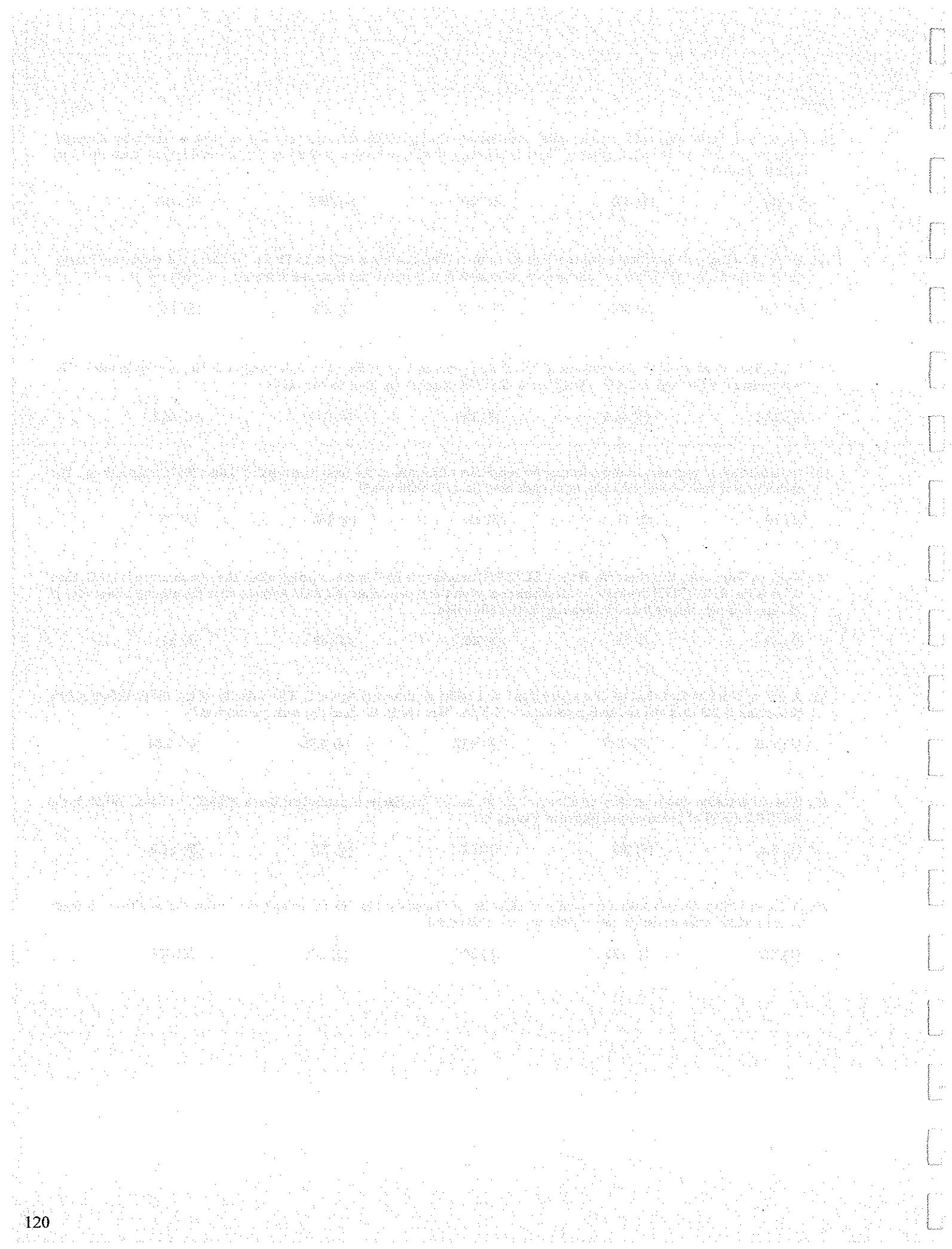
Formulas

$\sigma = 5.67 \times 10^{-8} \frac{W}{(m^2 \cdot K^4)}$	R = 8314 J/(kmol · K)
density of water = $1000 \text{ kg/m}^3 = 1 \text{ g/cm}^3 = 62.4 \text{ lb/ft}^3$	Heat of Vaporization of Water = 539 cal/g
Heat of Fusion of Water = 80 cal/g	Absolute Zero = -273°C
$k(\text{Boltzmann's constant}) = 1.38 \times 10^{-23} \text{ J/K}$	$g = 9.80 \text{ m/s}^2 = 32.2 \text{ ft/s}^2$
$C_{\text{steam}} = 0.46 \text{ cal/g} \cdot ^\circ\text{C}$	$C_{\text{water}} = 1 \text{ cal/g} \cdot ^\circ\text{C}$
$C_{\text{ice}} = 0.5 \text{ cal/g} \cdot ^\circ\text{C}$	$1 \text{ MPa} = 10^6 \text{ Pa}$
$N_A = 6.02 \times 10^{26}/\text{kmol} = 6.02 \times 10^{23}/\text{mol}$	$1 \text{ cal} = 4.184 \text{ J}$
1 atm = Atmospheric Pressure = $14.7 \text{ lb/in}^2 = 101 \text{ kPa} = 1.01 \times 10^5 \text{ Pa}$	$1 \text{ kcal} = 1000 \text{ cal} = 1 \text{ nutritionist's (food) Calorie}$

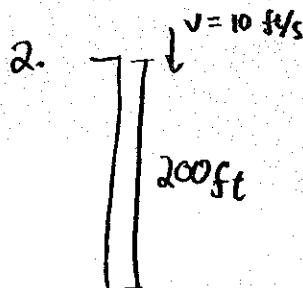
1. A frictionless pulley (see Figure 3) has two masses, $m_1 = 5 \text{ kg}$ and mass $m_2 = 1 \text{ kg}$, hanging from it. If the masses are released from rest, what is the tension (in N) in the cord? (Assume the pulley is massless.)
 (1) 16.3 (2) 3.3 (3) 10.8 (4) 4.7 (5) 32.9
2. From atop the Century Tower (200 ft tall), you throw a ball downward with an initial velocity (downward) of 10 ft/s. How long does it take (in seconds) to reach the bottom?
 (1) 3.2 (2) 5.4 (3) 7.5 (4) 1.2 (5) 0.9
3. If a pendulum has a speed of 24 cm/s as it passes through its lowest point, what angle (in degrees with respect to the vertical) was the pendulum released from? Assume friction is negligible and the length of the pendulum string is 80 cm.
 (1) 4.9 (2) 1.5 (3) 3.2 (4) 12.3 (5) 53.2

4. *A heavy solid cylinder is released from rest at the top of an inclined plane. When it reaches the bottom of the inclined plane, it is traveling at a (linear) speed of 2.1 m/s. How high (in m) is the inclined plane? Neglect the loss of energy due to friction. (NOTE: for a solid cylinder of mass m and radius b , the moment of inertia $I = (1/2)mb^2$.)
- (1) 0.34 (2) 0.73 (3) 0.52 (4) 1.56 (5) 2.64
5. A volume of gas is decreased from 1500 cm^3 to 200 cm^3 under a constant pressure of 2.2 MPa . How much work (in J) was done on the gas?
- (1) 2860 (2) -2860 (3) 2.86×10^9 (4) -2.86×10^9 (5) 2.86
6. 50 g of water at 60°C is completely converted to steam after adding 42000 cal. What is the final the final temperature (in $^\circ\text{C}$) of the steam? The heat capacity of steam is $0.46 \text{ cal}/(\text{g } -^\circ\text{C})$
- (1) 667 (2) 567 (3) 767 (4) 212 (5) 1003
7. How much heat (in J) will radiate each second from a star with a surface temperature of 15000°K , a surface area of $5 \times 10^{29} \text{ m}^2$, and an emissivity of 0.9?
- (1) 1.3×10^{39} (2) 7.6×10^{31} (3) 6.8×10^{37} (4) 1.5×10^{46} (5) 4.3×10^{51}
8. A piece of aluminum rod is 10 cm long and has a radius of 2 cm. If one end of the rod is held in boiling water (100°C) and the other end of the rod is held in ice water (0°C), how much heat (in cal) will flow through the rod in 10 s? The thermal conductivity of aluminum is $0.5 \text{ cal} / (\text{cm s } ^\circ\text{C})$.
- (1) 628 (2) 63 (3) 100 (4) 49 (5) 366
9. * A mass is attached to a spring. If the mass undergoes simple harmonic motion with a period of 2.5 s and a TOTAL DISPLACEMENT of 15 cm, what is the maximum speed of the mass (in m/sec)?
- (1) 0.19 (2) 0.38 (3) 1.14 (4) 0.62 (5) 2.29
10. A tube 4 m in length is open at one end and closed at the other end. What is the frequency of the first overtone? Assume the velocity of sound to be 340 m/sec.
- (1) 64 Hz (2) 21 Hz (3) 141.67 Hz (4) 113.3 (5) 56.67
11. Vector A has magnitude 20 and makes an angle of 45° with respect to the x-axis. Vector B has magnitude 28 and makes an angle of 90° with respect to the x-axis. What angle does the vector $C = A - B$ make with respect to the x-axis?
- (1) -44.4 (2) 71.5 (3) -71.5 (4) 44.4 (5) -45.6
12. The mass of Planet Y is nine times the mass of the Earth and its radius is two times the radius of earth. How many pounds will a man who weighs 160 lbs on Earth weigh on Planet Y?
- (1) 360 (2) 71 (3) 36 (4) 720 (5) 800

13. * A Carbon atom ($m_C = 12$ atomic units) with initial velocity of 300 m/s collides head on with a stationary Oxygen atom ($m_O = 16$ atomic units). If the collision is perfectly elastic, then what is the velocity of the Oxygen atom after the collision in m/s?
- (1) 257 (2) 300 (3) 350 (4) 250 (5) 360
14. A 7 kg bowling ball is rolling along the floor at 10 m/s. The ball has a radius of 12 cm. What is the rotational energy (in J) of the ball? (NOTE: for a solid sphere of mass m and radius b , the moment of interia $I = (\frac{2}{5}) m b^2$.)
- (1) 140 (2) 350 (3) 175 (4) 875 (5) 280
15. * A balloon vendor's tank has a volume of 0.5 m^3 and contains 5 kg of He_2 (the molar weight of He_2 is 8 kg/kmole). The temperature of the tank is 20°C . What is the GAUGE pressure (in atm) in the tank?
- (1) 29.1 (2) 30.1 (3) 120 (4) 119 (5) 28.1
16. An ideal Carnot engine operates between two reservoirs which are at the temperatures 30°C and 300°C respectively. For each 150 J of heat energy taken in, how much heat (in J) is exhausted?
- (1) 79 (2) 71 (3) 15 (4) 135 (5) 75
17. Refer to Table 1 for this question. If the RELATIVE humidity is 95% in the morning when the temperature is 20°C , then what is the RELATIVE humidity in the afternoon when the temperature is 32°C ? Assume that the absolute humidity of the air does not change from the morning to the afternoon.
- (1) 49 (2) 51 (3) 63 (4) 59 (5) 91
18. A 2.0 kg block strikes the end of a spring head and sticks as shown in figure 1. The velocity of the block before it hits the spring is 2.3 m/s and the spring constant is 5 N/m. How far in m, does the spring compress?
- (1) 1.45 (2) 2.12 (3) 0.92 (4) 5.75 (5) 3.64
19. The acceleration due to gravity on Planet Z is: 21 m/s^2 . On Earth, a pendulum has a PERIOD of 5 s. What is the PERIOD (in s) of the same pendulum on Planet Z?
- (1) 3.4 (2) 2.3 (3) 10.7 (4) 7.3 (5) 22.9
20. A 0.5 m string vibrates with a frequency of 1000 Hz. If the string has five nodes and four antinodes as shown in figure 2, then what is the speed (in m/s) of the waves on the string?
- (1) 250 (2) 125 (3) 500 (4) 100 (5) 300



1. Figure? sorry we don't know where this is.



$$\Delta X = V_0 \Delta t + \frac{1}{2} a \Delta t^2 \quad a = g = 32.2 \text{ ft/s}^2$$

$$\frac{1}{2} g \Delta t^2 + V_0 \Delta t - \Delta X = 0$$

$$16.1 \Delta t^2 + 10 \Delta t - 200 = 0$$

to simplify calculation let $16.1 \approx 16$
hence

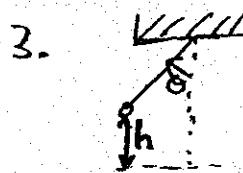
$$16 \Delta t^2 + 10 \Delta t - 200 = 0$$

Apply quadratic formula $x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$

$$\Delta t = \frac{-10 \pm \sqrt{100 + 12800}}{32} = \frac{-10 \pm 113.58}{32}$$

throw out negative, because negative time makes no sense hence,

$$\Delta t = \frac{-10 + 113.58}{32} = \boxed{3.2 \text{ sec}}$$



$$\frac{80 \text{ cm}}{1} \times \frac{1 \text{ m}}{1 \times 10^2 \text{ cm}} = 0.8$$

$$\frac{24 \frac{\text{m}}{\text{s}}}{1} \times \frac{1 \text{ m}}{1 \times 10^2 \text{ cm}} = 0.24 \frac{\text{m}}{\text{s}}$$

First convert to meters

Use conservation of energy

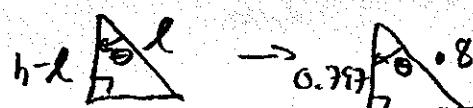
$$P.E. = K.E.$$

$$P.E. = mgh$$

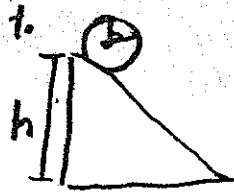
$$K.E. = \frac{1}{2} mv^2$$

$$h = \frac{1}{2g} v^2 = \frac{1}{2(9.8 \frac{\text{m}}{\text{s}^2})} (0.24 \frac{\text{m}}{\text{s}})^2 = 0.0029 \text{ m}$$

form the following right triangle



$$\text{hence } \theta = \cos^{-1}\left(\frac{0.0029}{0.80}\right) = \boxed{4.9^\circ}$$



USE conservation of energy

$$P.E. = K.E.$$

$$P.E. = mgh$$

K.E. = Translational + Rotational

$$\text{Translational} = \frac{1}{2}mv^2$$

$$\text{Rotational} = \frac{1}{2}I\omega^2 = \left(\frac{1}{2}\right)\left(\frac{1}{2}\right)mb^2 \left(\frac{v}{b}\right)^2 = \frac{1}{4}mv^2$$

$$mgh = \frac{1}{4}mv^2 + \frac{1}{2}mv^2 = \frac{3}{4}mv^2$$

$$mgh = \frac{3}{4}mv^2$$

$$h = \frac{3}{4} \frac{v^2}{g} = \frac{3}{4} \left(\frac{(2.1)^2}{(9.80)} \right) = [0.34 \text{ m}]$$

5.

$$W = -p\Delta V = -p(V_f - V_i) = - (2.2 \times 10^6 \text{ Pa}) (2 \times 10^{-4} \text{ m}^3 - 0.0015 \text{ m}^3)$$

$$= [2860 \text{ J}]$$

$$V_i = \frac{1500 \text{ cm}^3}{1} \times \frac{1 \text{ m}}{(1 \times 10^2 \text{ cm})^3} = 0.0015 \text{ m}^3$$

$$V_f = \frac{2000 \text{ cm}^3}{1} \times \frac{10}{(1 \times 10^2 \text{ cm})^3} = 2 \times 10^{-4} \text{ m}^3$$

$$P = 2.2 \text{ MPa} \times \frac{1 \times 10^6 \text{ Pa}}{1 \text{ MPa}} = 2.2 \times 10^6 \text{ Pa}$$

6. each water g will be brought to boiling point then evaporate the heat as steam

$$50 \text{ g} \left(\frac{100}{50^\circ \text{C}} \right) (10) + 50 (539 \text{ cal/g}) + 50 (1.46 \text{ cal/g}) (T_f - 100) = \\ 2000 \text{ cal} + 26950 \text{ cal} + 23 T_f - 2300 = 42,000$$

$$T_f = \underline{\underline{667^\circ \text{K}}}$$

$$7. \quad T = 15000\text{K}$$

$$\sigma = 5.6703 \times 10^{-8} \text{W/m}^2\text{K}^4$$

$$\text{Surface Area} = 5 \times 10^{29}$$

$$\text{emissivity} = 1.0$$

$$P_{\text{rad}} = \sigma \epsilon A T^4$$

$$P_{\text{rad}} = (5.6703 \times 10^{-8})(1.0)(5 \times 10^{29})(15000)^4 \text{W}$$

$$P_{\text{rad}} = 1.29 \times 10^{39} \text{W}$$

$$1.29 \times 10^{39} \text{W} = 1.29 \times 10^{39} \text{J/s} = \underline{\underline{1.29 \times 10^{39} \text{J} \text{ (in 1 sec)}}}$$

8

$$P = kA \frac{T_H - T_C}{2}$$

$$P = \frac{.5 \text{ cal}}{\text{cm} \cdot 5^\circ\text{C}} (\pi 2^2 \text{ cm}^2) \frac{(100-0)}{10 \text{ cm}} = 62.8 \text{ cal/s}$$

$$Q = 10s (62.8 \text{ cal/s}) = \underline{\underline{628 \text{ cal}}}$$



9. Δx is total displacement

$$\text{hence } x_m = \frac{\Delta x}{2} = 0.075\text{m}$$

$$V = \omega x_m \sin(\omega t) \quad \text{at max } V \sin(\omega t) = 1$$

$$\text{hence } V_m = \omega x_m \quad \omega = \frac{2\pi}{T} = \frac{2\pi}{2.5} = 2.5135^{\circ}\text{s}^{-1}$$

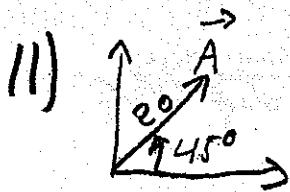
$$V_m = (2.5135^{\circ}\text{s}^{-1})(0.075\text{m}) = 0.19 \frac{\text{m}}{\text{s}}$$

10.

$$V_n = n \frac{\pi}{4L}, \quad n = 1, 3, 5$$

First overtone as $n = 3$

$$V_3 = \frac{(3)(340 \frac{\text{m}}{\text{s}})}{(4)(4\text{m})} = 64 \text{s}^{-1} = 64 \text{Hz}$$



Find the components of A and B, i.e. x_A, y_A, x_B, y_B

$$x_A = 20 \cos(45^\circ) = 10\sqrt{2}$$

$$x_B = 28 \cos(90^\circ) = 0$$

$$y_A = 20 \sin(45^\circ) = 10\sqrt{2}$$

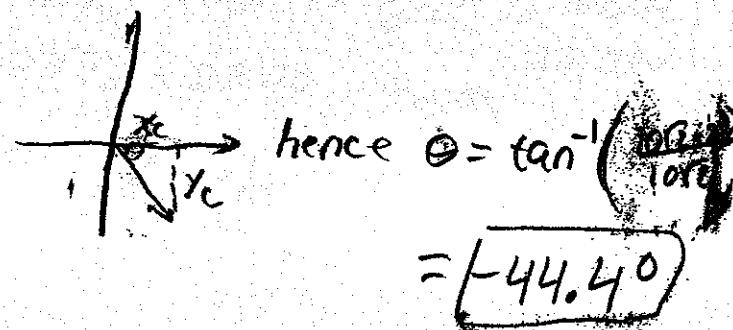
$$y_B = 28 \sin(90^\circ) = 28$$

hence ...

$$\vec{A} = \langle 10\sqrt{2}, 10\sqrt{2} \rangle$$

$$\vec{B} = \langle 0, 28 \rangle$$

$$\vec{C} = \vec{A} - \vec{B} = \langle 10\sqrt{2}, 10\sqrt{2} - 28 \rangle$$



$$12) Ry = 2R_E$$

$$M_N = 9M_E$$

$$g_E = \frac{GM_E}{R_E^2}$$

$$g_P = \frac{9}{4} \frac{M_E}{R_E^2}$$

$$\text{hence } w_E \perp g_E \Rightarrow w_N = \frac{9}{4} w_E = \frac{9}{4}(160) = \boxed{360 \text{ lbs}}$$

13. MOMENTUM IS CONSERVED: $(m_1 \cdot v_1 = m_2 \cdot v_2)$

C₁₂ INITIAL VELOCITY = 300 m/s

mass: 12 atomic units

O₁₆ INITIAL VELOCITY = 0 m/s (STATIONARY)

mass: 16 atomic units

ELASTIC COLLISION \Rightarrow ENERGY CONSERVED

$$\sum m_i v_i^2 = \sum m_i v_f^2 \quad (KE_{\text{initial}} = KE_{\text{final}})$$

FOR PROBLEM 13, THERE ARE TWO SETS OF MASSES: CARBON & OXYGEN. EACH MUST BE INCLUDED IN THE ABOVE EQUATIONS SO:

(MOMENTUM)

$$(m_{C_12} \cdot v_{C_12}) + (m_{O_{16}} \cdot v_{O_{16}}) = (m_{C_12} \cdot v_{C_f}) + (m_{O_{16}} \cdot v_{O_f})$$

(ENERGY)

$$v_{C_12}^2 m_{C_12} + v_{O_{16}}^2 m_{O_{16}} = v_{C_f}^2 m_{C_12} + v_{O_f}^2 m_{O_{16}}$$

\Rightarrow SINCE v_{O_f} (INITIAL VELOCITY OF OXYGEN) IS ZERO, THIS CAN BE ELIMINATED FROM THE EQUATION

(MOMENTUM)

$$m_{C_12} \cdot v_{C_12} = m_{C_12} \cdot v_{C_f} + m_{O_{16}} \cdot v_{O_f} \quad \sum m_i v_i^2 = \sum m_i v_f^2 + \sum m_i v_i^2$$

$$m_{C_12} \cdot v_{C_12} - m_{C_12} \cdot v_{C_f} = m_{O_{16}} \cdot v_{O_f}$$

$$v_{O_f} = \frac{m_{C_12} \cdot v_{C_12} - m_{C_12} \cdot v_{C_f}}{m_{O_{16}}}$$

$$v_{O_f} = v_{C_12} - \left(\frac{m_{C_12}}{m_{O_{16}}}\right) v_{C_f}$$

(ENERGY)

$$m_{C_12} \cdot v_{C_12}^2 = m_{C_12} \cdot v_{C_f}^2 + m_{O_{16}} \cdot v_{O_f}^2$$

$$m_{C_12} \cdot v_{C_12}^2 - m_{C_12} \cdot v_{C_f}^2 = m_{O_{16}} \cdot v_{O_f}^2$$

\Rightarrow SINCE THE FINAL VELOCITY OF CARBON WAS NOT GIVEN, WE SOLVED FOR IT USING THE MOMENTUM EQUATION. THE ENERGY EQUATION WAS SOLVED TO FIND THE FINAL VELOCITY OF OXYGEN. BY SUBSTITUTING THE FINAL CARBON VELOCITY FOUND IN THE MOMENTUM EQUATION INTO THE ENERGY EQUATION, WE CAN CALCULATE THE FINAL OXYGEN VELOCITY.

$$m_{C_12} \cdot v_{C_12}^2 - m_{C_12} \left(v_{C_12} - \frac{m_{C_12}}{m_{O_{16}}} v_{O_f}\right)^2 = m_{O_{16}} \cdot v_{O_f}^2$$

$$m_{C_12} \cdot v_{C_12}^2 - m_{C_12} \left(v_{C_12}^2 - 2 \frac{m_{C_12}}{m_{O_{16}}} \cdot v_{C_12} \cdot v_{O_f} + \frac{m_{C_12}^2}{m_{O_{16}}^2} \cdot v_{O_f}^2\right) = m_{O_{16}} \cdot v_{O_f}^2$$

$$m_{C_12} \cdot v_{C_12}^2 - m_{C_12} \cdot v_{C_12}^2 + m_{C_12} \cdot 2 \frac{m_{C_12}}{m_{O_{16}}} \cdot v_{C_12} \cdot v_{O_f} - m_{C_12} \cdot \frac{m_{C_12}^2}{m_{O_{16}}^2} \cdot v_{O_f}^2 = m_{O_{16}} \cdot v_{O_f}^2$$

$$(2 \cdot m_{C_12} \cdot v_{C_12}) v_{O_f} - \left(\frac{m_{C_12}^2}{m_{O_{16}}}\right) v_{O_f}^2 = m_{O_{16}} \cdot v_{O_f}^2$$

$$(2 \cdot m_{C_12} \cdot v_{C_12}) v_{O_f} = \left(\frac{m_{C_12}^2}{m_{O_{16}}} + m_{O_{16}}\right) v_{O_f}^2$$

$$2 \cdot m_{C_12} \cdot v_{C_12} = \left(\frac{m_{C_12}^2}{m_{O_{16}}} + m_{O_{16}}\right) v_{O_f}$$

$$v_{O_f} = \frac{2 \cdot m_{C_12} \cdot v_{C_12}}{\frac{m_{C_12}^2}{m_{O_{16}}} + m_{O_{16}}}$$

\Rightarrow SUBSTITUTING VALUES GIVES:

$$v_{O_f} = \frac{2 \cdot 12 \cdot 300}{\frac{12^2}{16} + 16} = 257 \text{ m/s}$$

14. ROTATIONAL ENERGY \Rightarrow K_E
 $MOMENT\ OF\ INERTIA = I$

$$K_E = \frac{1}{2} I \left(\frac{v}{r}\right)^2$$

$$I = \frac{1}{2} M \cdot r^2$$

v = VELOCITY
 r = RADIUS
 m = MASS

SUBSTITUTING MOMENT OF INERTIA (I) INTO K_E WE GET:

$$\begin{aligned} K_E &= \frac{1}{2} \left(\frac{1}{2} M \cdot r^2 \right) \left(\frac{v}{r} \right)^2 \\ &= \frac{1}{4} M \cdot r^2 \cdot \frac{v^2}{r^2} \\ &= \frac{1}{4} M \cdot v^2 \end{aligned}$$

SUBSTITUTING NUMERICAL VALUES:

$$K_E = \frac{1}{4} M \cdot v^2 = 140 J$$

15. IDEAL GAS LAW: $P \cdot V = nRT$ | P = TOTAL PRESSURE

$$P = \frac{RnT}{V}$$

$$T = 20^\circ C = (20 + 273.15)^\circ K = 293.15^\circ K$$

$$n = \frac{\text{MASS}}{\text{MOLAR WEIGHT}} = \frac{5 \text{ kg}}{8 \text{ kg/mol}}$$

$$V = 0.5 \text{ m}^3$$

$$P = \frac{(8314 \text{ J/kg.K}) \left(\frac{5 \text{ kg}}{8 \text{ kg/mol}} \right) (293.15^\circ K)}{0.5 \text{ m}^3} \times \frac{1 \text{ Pa}}{10^5 \text{ N/m}^2} \times \frac{1 \text{ atm}}{(1.013 \times 10^5 \text{ Pa})} = 30.1 \text{ atm}$$

*THE QUESTION ASKS FOR GAUGE PRESSURE, WHICH EXCLUDES THE INITIAL PRESSURE OF THE SYSTEM. IN THIS CASE, IT DOES NOT INCLUDE ATMOSPHERIC PRESSURE. SINCE ATMOSPHERIC PRESSURE IS APPROXIMATELY 1ATM, THIS AMOUNT SHOULD BE SUBTRACTED FROM THE CALCULATED TOTAL PRESSURE.

$$\text{GAUGE PRESSURE} = 30.1 \text{ atm} - 1 \text{ atm} = 29.1 \text{ atm}$$

16. CARNOT ENGINE EFFICIENCY: $1 - n$ | $n = \frac{T_c}{T_h}$ | $T_c = 30^\circ C = 303^\circ K$
 $T_h = 300^\circ C = 573^\circ K$

ENERGY EXHAUSTED, OR LOST, IS n PERCENT. THE TOTAL VALUE IS THUS ENERGY INTAKE TIMES n :

$$150 \text{ J} \times \left(\frac{303^\circ K}{573^\circ K} \right) = 79 J$$

17. fail? sorry we don't know where this is

18. ASSUMING AN ELASTIC COLLISION (BECAUSE THE QUESTION DOES NOT STATE OTHERWISE), ENERGY IS CONSERVED. THUS, THE FINAL POTENTIAL ENERGY OF THE COMPRESSED SPRING IS EQUAL TO THE INITIAL KINETIC ENERGY OF THE MOVING BLOCK. \Rightarrow PE OF SPRING IS $\gamma_Z kx^2$; v = velocity KE OF BLOCK IS $\gamma_Z m v^2$ m = mass

$$PE_f = KE_i$$

$$\gamma_Z \cdot k \cdot x^2 = \gamma_Z \cdot m \cdot v^2$$

$$k \cdot x^2 = m \cdot v^2$$

$$x^2 = \frac{v^2 \cdot m}{k}$$

$$x = v \cdot \sqrt{\frac{m}{k}} \Rightarrow x = 23 \text{ ms} \cdot \sqrt{\frac{20 \text{ Nm}}{5 \text{ Nm}}} = 1.45 \text{ m}$$

k = spring constant
 x = distance spring compresses

19. THE PERIOD OF A PENDULUM IS RELATED TO LENGTH AND ACCELERATION DUE TO GRAVITY.

$$T = 2\pi \sqrt{\frac{l}{g}}$$

| T = period
 l = length
 g = acceleration due to gravity

ON PLANET Z:

$$T_z = 2\pi \sqrt{\frac{l_z}{g_z}}$$

ON EARTH:

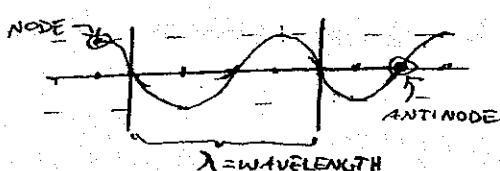
$$T_e = 2\pi \sqrt{\frac{l_e}{g_e}}$$

WE WANT TO KNOW THE PERIOD ON PLANET Z. THE ONLY UNKNOWN IS THE PENDULUM LENGTH, WHICH SHOULD BE THE SAME ON BOTH PLANETS BECAUSE THE SAME PENDULUM IS IN USE. THE SIMPLEST WAY TO SOLVE FOR BOTH EQUATIONS IS TO SET THEM AS RATIOS:

$$\frac{T_z}{2\pi \sqrt{\frac{l_z}{g_z}}} = \frac{T_e}{2\pi \sqrt{\frac{l_e}{g_e}}} \Rightarrow \sqrt{\frac{l_z}{g_z}} = \frac{T_e}{\sqrt{\frac{l_e}{g_e}}} \Rightarrow T_z = T_e \cdot \sqrt{\frac{l_z}{g_z}} \Rightarrow T_z = T_e \sqrt{\frac{g_e}{g_z}}$$

$$T_z = 5 \text{ s} \cdot \sqrt{\frac{9.8 \text{ m/s}^2}{21 \text{ m/s}^2}} = 3.4 \text{ s}$$

20. SPEED OF A WAVE IS: $v = f \cdot \lambda$; WHERE f IS FREQUENCY & λ IS WAVELENGTH. SINCE THE LENGTH OF STRING CONTAINS 5 NODES & 4 ANTINODES, WE KNOW THE STRING MEASURES $2 \cdot \lambda$:



$$L = 2\lambda \quad v = f \cdot \lambda$$

$$\lambda = \gamma_Z L \quad v = \gamma_Z \cdot f \cdot L$$

$$v = 250 \text{ m/s}$$

Instructor: B. Whiting, H.-P. Cheng

PHYSICS DEPARTMENT

PHY 2004

Exam 3

April 7, 2003

Name (print, last first):

Signature:

On my honor, I have neither given nor received unauthorized aid on this examination.

YOUR TEST NUMBER IS THE 5-DIGIT NUMBER AT THE TOP OF EACH PAGE.

- (1) Code your test number on your answer sheet (use 76-80 for the 5-digit number). Code your name on your answer sheet. DARKEN CIRCLES COMPLETELY. Code your student number on your answer sheet.

(2) Print your name on this sheet and sign it also.

(3) Do all scratch work anywhere on this exam that you like. At the end of the test, this exam printout is to be turned in. No credit will be given without both answer sheet and printout with scratch work most questions demand.

(4) Blacken the circle of your intended answer completely, using a #2 pencil or blue or black ink. Do not make any stray marks or the answer sheet may not read properly.

(5) The answers are rounded off. Choose the closest to exact.
There is no penalty for guessing.

>>>>>> **WHEN YOU FINISH** <<<<<<
Hand in the answer sheet separately.

$\rho_{\text{water}} = 1000 \text{ kg/m}^3$	$\alpha_{\text{steel}} = 12 \times 10^{-6}/^\circ\text{C}$
$c_{\text{water}} = 4184 \text{ J/kg/}^\circ\text{C}$	$N_a = 6.022 \times 10^{26} \text{ particles/kmol}$
$k = 1.3806 \times 10^{-23} \text{ J/K}$	$H_V(\text{steam}) = 539 \text{ cal/g}$
$\sigma = 5.67 \times 10^{-8} \text{ W/m}^2/\text{K}^4$	

1. A 3.0-cm radius water main in the basement has 500 kPa gauge pressure when a 1.0-cm radius pipe in the second floor 5 meters above the main breaks. How much water leaks out per minute? (in m³ per minute)

(1) 0.57 (2) 1.25 (3) 25.6 (4) 0.06 (5) 2.8

2. It is estimated that the temperature of the sun's interior is 10×10^6 K. What is the average speed of a hydrogen atom ($m = 1\text{kg}/\text{kmol}$) in a gas at this temperature (in m/s)?

(1) 5.0×10^5 (2) 60 (3) 0.20 (4) 3×10^9 (5) 7000.0

3. How many grams of hot steam at 130°C are needed to heat 1000 g of water at 50°C to 90°C? ($C_{\text{water}} = 1 \text{ cal/g}^\circ\text{C}$, $C_{\text{steam}} = 0.46 \text{ cal/g}^\circ\text{C}$)

(1) 71.1 (2) 36.2 (3) 326.3 (4) 0.5 (5) 13.8

4. Which of the following statements is incorrect?

(1) Net heat can flow even between two reservoirs at the same temperature.
(2) Heat flows spontaneously from a hot object to a cold one.
(3) Heat energy can be converted to mechanical energy.
(4) Absolute zero temperature T=0°K cannot be reached.
(5) If two objects are in equilibrium, they must share the same temperature.

5. The temperature of the sun's surface is 5500 K. How much heat does it radiate in a day assuming the sun is a blackbody (in J)? ($R_{\text{sun}} = 7 \times 10^8 \text{ m}$)

(1) $2.8 \times 10^{31} \text{ J}$ (2) $3.6 \times 10^{20} \text{ J}$ (3) 560.2 (4) $4.3 \times 10^{50} \text{ J}$ (5) $3.9 \times 10^6 \text{ J}$

6. On a day when atmospheric pressure is exactly 100 kPa, what is the total pressure 5 m deep in a freshwater lake?
- (1) 149 kPa (2) 101 kPa (3) 595 kPa (4) 52 kPa (5) 106 kPa
7. A steel measuring tape is 10.000 m long at 20°C. How much longer will it be at 30°C?
- (1) 1.2 mm (2) .012 mm (3) 12.0 mm (4) 120 mm (5) 0.12 m
8. A 75-W light bulb is painted black so that it emits no light. Its total power is then released as heat. How long would the bulb take to heat 1500 g of water by 40°C if the bulb is completely submerged?
- (1) 55.8 min (2) 25.0 min (3) 1.5 min (4) 4200 min (5) 0.5 min
9. If a Carnot engine has its cold reservoir at 10°C, what must be the temperature of its hot reservoir if its efficiency is to be 80 percent?
- (1) 1142°C (2) 1420°C (3) 52°C (4) 1690°C (5) 325°C
10. In order to determine the thermal conductivity of a material, one measures the heat flow through it. It is found that 500 cal flows in 1 min through a 3-cm² area that is 2 mm thick. The temperature difference is maintained at 30°C. What is k for this material, in J/(m)(s)(°C)?
- (1) 7.75 (2) 1.84 (3) 6.98×10^3 (4) 466 (5) 0.47

1) Bernoulli's equation

$$① \frac{1}{2} \rho v_1^2 + \rho gh + P_1 = \frac{1}{2} \rho v_2^2 + \rho gh + P_2$$

and conservation of mass

$$A_1 v_1 = A_2 v_2$$

now from ①

$$\Rightarrow v_1 = \frac{A_2}{A_1} v_2$$

$$\frac{1}{2} \rho v_2^2 \left(1 - \frac{A_2^2}{A_1^2}\right) = P_1 - P_2 + \rho g(h_1 - h_2)$$

↑ pos. circ. lat zero

$$= P_1 - \rho gh$$

solving for v_2

$$v_2 = \sqrt{\frac{2(P_1/\rho - gh)}{(1 - A_2^2/A_1^2)}} = 31 \text{ m/s}$$

$$Q_{\text{rate}} = 31 \pi (1.01)^2 \cdot 60 \text{ s} \\ = 584 \text{ m}^3/\text{min}$$

2)

$$v_{\text{rms}} = \sqrt{\frac{3RT}{M}}$$

$$M = \frac{1 \text{ kg}}{1 \text{ kmol}} = \frac{0.001 \text{ kg}}{\text{mol}}$$

$$T = 10 \times 10^3 \text{ K}$$

$$R = 8.31 \text{ J/mol} \cdot \text{K}$$

$$v_{\text{rms}} = \sqrt{\frac{3(8.31)(10 \times 10^3)}{0.001}} = 4,99 \times 10^3 \text{ m/s}$$

3) First calculate the calories needed to heat the 1000g of $H_2O(l)$

$$\frac{1 \text{ cal}}{9^\circ\text{C}} \left| \begin{array}{c} 1000\text{g} \\ | \end{array} \right| \frac{40^\circ\text{C}}{\checkmark} = 40,000 \text{ cal}$$
$$90-50 = 40^\circ\text{C} = \Delta T$$

Now calculate the amount of calories per gram u get from the steam

stage 1: cooling vapor

water boils at 100°C

$$\frac{46 \text{ cal}}{9^\circ\text{C}} \left| \begin{array}{c} 30^\circ\text{C} \\ | \end{array} \right| = 13.8 \text{ cal/g}$$
$$\Delta T = 130 - 100 = 30^\circ\text{C}$$

Stage 2: sublimation

539 cal/g

Stage 3: cool liquid $\Delta T = 100 - 90 = 10^\circ\text{C}$

$$\frac{1 \text{ cal}}{9^\circ\text{C}} \left| \begin{array}{c} 10^\circ\text{C} \\ | \end{array} \right| = 10 \text{ cal/g}$$

Total energy = stage 1 + stage 2 + stage 3

$$= 562 \text{ cal/g}$$

Now set this equal to the calories to heat the water

$$M_{\text{steam}} \left(\frac{562 \text{ cal}}{\text{g}} \right) = 40,000 \text{ cal}$$

$$M_{\text{steam}} = \underline{71.1 \text{ g}}$$

- 4) Statement one is incorrect because a system will flow towards its equilibrium point. If the two systems are at the same temperature they are in equilibrium.

5)

$$P_{\text{rad}} = \sigma A T^4 \quad \text{where } \sigma = 5.6703 \times 10^{-8} \text{ W/m}^2 \cdot \text{K}^4$$

T = temperature in kelvin
 A = surface area

$$A = 4\pi R_{\text{sun}}^2 = 6.158 \times 10^{18} \text{ m}^2$$

$$\theta = 5500 \text{ K}$$

$$P_{\text{rad}} = (5.6703 \times 10^{-8}) (6.158 \times 10^{18}) (5500)^4$$
$$P_{\text{rad}} = 3.195 \times 10^{26} \text{ W}$$

now convert this to energy per day ($1W = 1J/s$)

$$\frac{3.195 \times 10^{26} J}{s} \left| \begin{array}{c} 60s \\ 1\text{ min} \end{array} \right| \left| \begin{array}{c} 60\text{ min} \\ 1\text{ hr} \end{array} \right| \left| \begin{array}{c} 24\text{ hr} \\ 1\text{ day} \end{array} \right|$$
$$= 2.8 \times 10^{31} J$$

6) $P = P_0 + \rho gh$ where P_0 = pressure at surface

ρ = density of water

h = depth

g = gravity

$$P = 100kPa + \frac{1000kg/m^3(9.8m/s^2)}{m^3}(5m)$$

$$P = 100kPa + 49000 Pa$$

$$P = 100kPa + 49kPa$$

$$P = 149kPa$$

8) first calculate energy needed to heat the water

$$J = \frac{1\text{ cal}}{g\text{ }^{\circ}\text{C}} \left| \begin{array}{c} 1500g \\ 40^{\circ}\text{C} \end{array} \right| = 60,000 \text{ cal}$$

$$\frac{60000 \text{ cal}}{1\text{ cal}} \left| \begin{array}{c} 4.195 \end{array} \right| = 2.519 \times 10^5 \text{ J}$$

$75W = 75J/s$ at this rate how long does it take to get out the required energy?

$$(75J/s) \text{ time} = 2.514 \times 10^5 J$$

$$\text{time} = 3352 s = \frac{3352 s}{60 s} \text{ min}$$
$$= \underline{\underline{55.87 \text{ min}}}$$

9) Efficiency of Carnot = $1 - \frac{T_1}{T_2}$ ✓ T must be in Kelvin!

$$.8 = 1 - \frac{283K}{T_2}$$

$$T_{\text{Kelvin}} = T_{\text{Celsius}} + 273$$

$$\frac{283K}{T_2} = .2$$

$$T_2 = \frac{283K}{.2} = 1415K$$

$$1415K = 1415 - 273 = \underline{\underline{1142^\circ C}}$$

7.)

Elongation of rod = length • Δ Temperature • α_{steel}

$$= \frac{10m | 10^\circ C | 12 \times 10^{-6}}{^\circ C} = 12 \times 10^{-4} m$$

$$= \underline{\underline{1.2 \text{ mm}}}$$

10) First convert units

$$\frac{500 \text{ cal}}{1} \times \frac{4.18 \text{ J}}{1 \text{ cal}} = 2090 \text{ J} = Q$$

$$\frac{3 \text{ cm}^2}{1} \times \frac{(1 \times 10^{-2})^2}{1 \text{ cm}^2} = 3.0 \times 10^{-4} \text{ m}^2 = A$$

$$2 \text{ mm} = 2 \times 10^{-3} \text{ m} = y$$

$$1 \text{ min} = 60 \text{ s} = t$$

$$T = 30^\circ \text{C}$$

$$\frac{Q}{At} = \lambda \frac{T}{y}$$

+ thermal conductivity

$$\text{Hence } \frac{Q \cdot y}{At \cdot T} = \lambda = \frac{(2090 \text{ J})(2 \times 10^{-3} \text{ m})}{(3.0 \times 10^{-4} \text{ m}^2)(60 \text{ s})(30^\circ \text{C})}$$

$$= \boxed{7.75 \frac{\text{J}}{\text{m} \cdot \text{s} \cdot \text{C}^\circ}}$$

PHY2004
Stanton

|||||||

NAME

(PRINT) -----

PHYSICS DEPARTMENT

Exam #3

November 20, 1996

(SIGNATURE) -----

PLEASE SIGN THE SHEET AT THE TOP. THIS INDICATES THAT ON YOUR HONOR,
YOU HAVE NOT GIVEN OR RECEIVED UNAUTHORIZED AID ON THIS EXAMINATION.

DIRECTIONS

- (1) Code your test number on your green answer sheet (use 76-80 for the 5-digit number). Code your name and student number on your answer sheet. Darken circles completely (errors can occur if too light).
- (2) Print your name on this sheet and sign it also.
- (3) Do all scratch work below the questions, and anywhere else on this exam. At the end of the test, this exam printout is to be turned in.

No credit will be given without both the answer sheet and printout, with the scratch work which most questions demand of anyone.

- (4) Work the questions in any order. Incorrect answers are not taken into account in any way; you may guess at answers you don't know if you feel that a correct answer is listed.
- (5) Black the circle of your intended answer completely, using a number 2 pencil on the answer sheet. Do not make any stray marks or the answer sheet may not read properly.
- (6) As an aid to the examiner (and yourself) in the case of poorly marked answer sheets, please circle your selected answer on the examination sheet.
- (7) Good luck!!!!

>>>>> BEFORE YOU FINISH <<<<<

Fold the computer print out so your name is on top, include any figure sheet inside the print out. Hand in the green answer sheet separately.

If none of the answers to a question are correct, please leave the answer sheet blank. It is not our intention to omit the right answer, but in case of a mistake by the instructor, please leave the answer sheet blank.

$$\text{density of water} = 1000 \text{ kg/m}^3 = 1 \text{ g/cm}^3 = 62.4 \text{ lb/ft}^3$$

$$1 \text{ atm} = \text{Atmospheric Pressure} = 14.7 \text{ lb/in}^2 = 101 \text{ kPa} \quad \text{Heat of Vaporization of Water} = 539 \text{ cal/g}$$

$$\text{Heat of Fusion of Water} = 80 \text{ cal/g}$$

$$k_B \text{ (Boltzmann's constant)} = 1.38 \times 10^{-23} \text{ J/K}$$

$$N_A = 6.02 \times 10^{26} / \text{kmol} = 6.02 \times 10^{23} / \text{mol}$$

$$g = 9.8 \text{ m/s}^2 = 32.2 \text{ ft/s}^2$$

$$R = 8314 \text{ (J/kmol K)}$$

$$C_{\text{water}} = 1 \text{ cal/(g}\cdot^\circ\text{C)}$$

$$C_{\text{steam}} = 0.46 \text{ cal/(g-}^{\circ}\text{C)}$$

$$C_{\text{ice}} = 0.5 \text{ cal/(g-}^{\circ}\text{C)}$$

$$1 \text{ cal} = 4.184 \text{ J}$$

$$1 \text{ GPa} = 1.0 \times 10^9 \text{ Pa}$$

$$1 \text{ kcal} = 1000 \text{ cal} = 1 \text{ nutritionist's Calorie}$$

1. A submarine is under water at a depth of 1600 m (approximately 1 mile). What is the pressure on the hull of the submarine? Give the answer in units of atm, atmospheric pressure ($1 \text{ atm} = 1.01 \times 10^5 \text{ Pa}$). Assume that ocean water has the same density as regular water.

1. 156
2. 15.8
3. 35,000
4. 1.6×10^5
5. 78

2. A certain fluid compresses by 0.5 PERCENT under a pressure of 7 MPa ($1 \text{ MPa} = 10^6 \text{ Pa}$). What is the BULK MODULUS for this fluid in GPa ($1 \text{ GPa} = 10^9 \text{ Pa}$)?

1. 1.4
2. 0.014
3. -0.014
4. 14
5. 3.5

3. An iron girder has a cross sectional area of 100 cm^2 . How large a compressive force (in newtons) is required to shorten the girder by 0.03 PERCENT? Use the table 1 given on the figure sheet.

1. 2.7×10^5
2. 3.0×10^7
3. 2.7×10^{-4}
4. 2.1×10^9
5. 3.0×10^5

4. An object weighs 12.5 N in air and has a volume of 350 cm^3 . How much will it APPEAR to weigh (in N) when completely submerged in water?

1. 9.1
2. 12.2
3. 12.9
4. 5.6
5. 9.9

5. The PRESSURE GAUGE on a 3000-cm³ tank of nitrogen reads 750 kPa. How much volume (in cm³) will the nitrogen occupy at the pressure of the outside air, 100 kPa? Assume temperature is constant.
1. 2.55×10^4
 2. 2.25×10^4
 3. 2250
 4. 400
 5. 3.53×10^4
6. Ten kilograms of helium gas ($M = 4 \text{ kg/kmol}$) are contained in a 1.0m³ tank at 30°C. What is the ABSOLUTE pressure in the tank? Give your answer in Pa.
1. 6.3×10^6
 2. 1.0×10^6
 3. 6.2×10^5
 4. 1.0×10^7
 5. 1.0×10^4
7. * On a winter day in Anchorage, Alaska, the temperature is -20°C. What is the average velocity (in m/s) of a nitrogen molecule (28 kg/kmol)?
1. 475
 2. 510
 3. 133
 4. 274
 5. 336
8. How many atoms are there in 12 kg of helium? ($M_{\text{He}} = 4 \text{ kg/kmol}$).
1. 1.8×10^{27}
 2. 1.8×10^{24}
 3. 2.0×10^{26}
 4. 2.0×10^{24}
 5. 2.4×10^{27}
9. The coefficient of linear expansion for steel is $12 \times 10^{-6} /^\circ\text{C}$. By what PERCENTAGE would a steel bridge contract from the hottest day of the year (37°C) to the coldest day of the year (-20°C)?
1. 0.068
 2. 6.8×10^{-4}
 3. 0.020
 4. 0.044
 5. 0.37

10. * How many grams of steam at 180°C are needed to raise the temperature of 500 grams of water from 20°C to 85°C ? $C_{\text{steam}} = 0.46 \text{ cal}/(\text{g}\cdot^{\circ}\text{C})$.
1. 55
 2. 60
 3. 740
 4. 40
 5. 247
11. Mount Everest is about 8850 m tall. Ideally, how many kcal (i.e. nutritionist's Calories) would a 75 kg man burn off if he climbed straight to the top? (Assume the body is 100% efficient and neglect any work not associated with the change in height. In reality, one would need many more calories.)
1. 1550
 2. 1.6×10^6
 3. 6500
 4. 1.6×10^5
 5. 2.7×10^4
12. * 300 g of water at a temperature of 95°C is mixed with 500 g of water at 20°C . What is the final temperature of the water after mixing?
1. 48
 2. 67
 3. 92
 4. 58
 5. 53
13. How much heat (in cal) is needed to change 40 g of ice at -20°C into water at 30°C ? Note that $C_{\text{ice}} = 0.5 \text{ cal}/(\text{g}\cdot^{\circ}\text{C})$.
1. 4800
 2. 1600
 3. 5200
 4. 3200
 5. 4400
14. An ideal gas is confined to a cylinder by a 10 kg piston as shown in figure 1. When 56 J of heat is added to the gas, the piston raises by 50 cm. What is the change in internal energy of the gas in Joules?
1. 7
 2. 49
 3. 56
 4. 51
 5. 0

15. A 50-g block of substance with a specific heat capacity of $2.3 \text{ cal/g}\cdot^{\circ}\text{C}$ is heated up 40°C . Assuming the volume change to be negligible, how much did the internal energy U increase? Give your answer in JOULES.
1. 1.92×10^4
 2. 4600
 3. 46
 4. 1099
 5. 19.2
16. *What must be the temperature of the Hot Reservoir (IN CELSIUS) for an IDEAL CARNOT engine that exhausts to a Cold Reservoir at a temperature 20°C (i.e. room temperature) if the engine is 50% efficient?
1. 313
 2. 586
 3. 40
 4. 313
 5. 10
17. A certain heat engine has an efficiency of 30%. For each 1000 J of heat energy that it takes in, how much heat (in J) does it exhaust?
1. 700
 2. 300
 3. 3000
 4. 333
 5. 1000
18. A 10 ft^2 sheet of material allows 250 BTU to flow through it in 30 min when the temperature difference across the sheet is 50°F . What is the R-value for the sheet?
1. 1
 2. 60
 3. 4
 4. 15
 5. 20
19. An aluminum frying pan is 12.5 cm in radius and is 1 mm thick. It is placed on a hot burner that has a temperature of 130°C . Meat on the inside of the skillet is at temperature of 70°C . How much heat, in cal, is conducted through the bottom of the frying pan in 1 minute? The thermal conductivity of aluminum is $k = 0.5 \text{ cal}/(\text{cm}\cdot\text{s}\cdot^{\circ}\text{C})$.
1. 8.8×10^6
 2. 2.8×10^6
 3. 1.8×10^5
 4. 8.8×10^5
 5. 2.8×10^5

20. Refer to table 2. What thickness (in inches) of cork would give the same insulation as 6 inches of brick?

1. 0.36
2. 100
3. 0.97
4. 0.30
5. 0.42

Figure 1

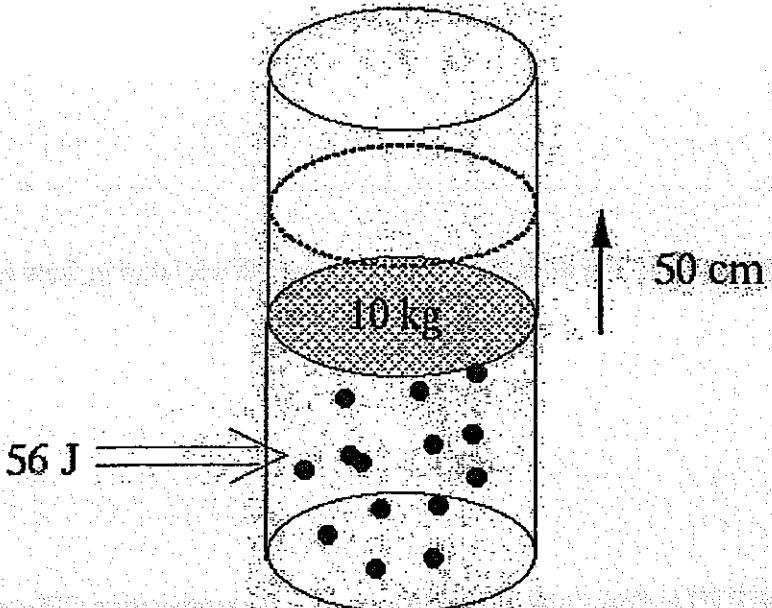


Table 1

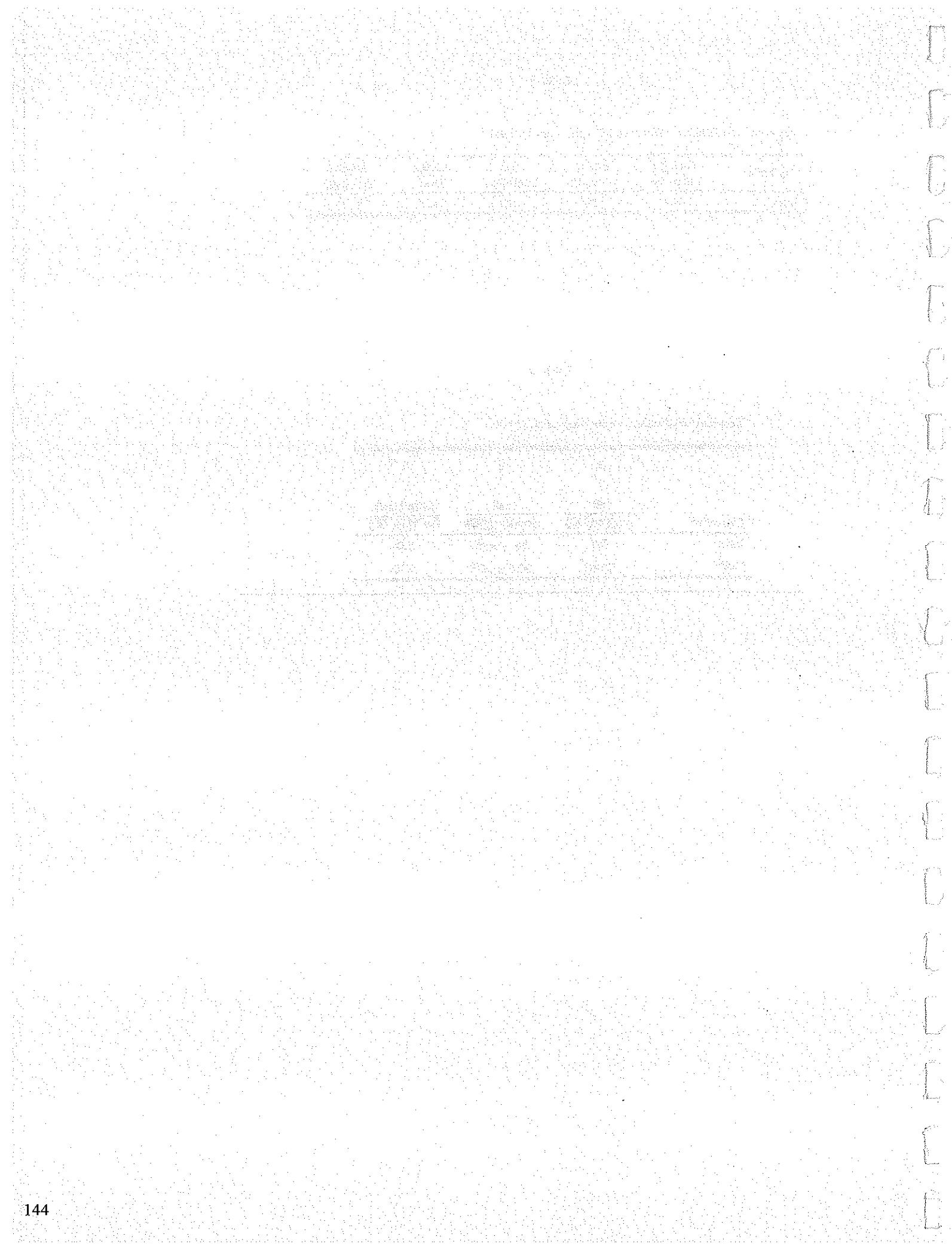
Approximate Elastic Properties (all values are in GPa)

Material	Young's Modulus	Shear Modulus	Bulk Modulus	Elastic Limit	Tensile Strength
Incon	90	70	100	0.17	0.32

Table 2

Thermal conductivity k for various materials.

Material	k	k	k
	(m)(s)(°C)	(cm)(s)(°C)	(Btu)(in) (ft²)(s)(°F)
Brick	0.7	17×10^{-4}	5.0
Cork	0.042	10.0×10^{-5}	0.30



Exam #3 1996

1)

$$P = P_0 + \rho gh$$

$$P = 1.01 \times 10^5 + 1000 \text{ kg/m}^3 (9.8 \text{ m/s}^2) (1600 \text{ m})$$

$$P = 1.5981 \times 10^7 \text{ Pa} = \frac{1.5981 \times 10^7 \text{ Pa}}{1.01 \times 10^5 \text{ Pa}}$$

$$= 156.2 \text{ atm}$$

2)

$$P = B \frac{\Delta V}{V}$$

$$7 \times 10^6 = B(0.005)$$

$$B = 14 \times 10^9 \text{ Pa} = 14 \text{ GPa}$$

$$3) 100 \text{ cm}^2 = 100 \text{ cm} \times 1 \text{ cm} = 1 \text{ m} \times 0.01 \text{ m} = .01 \text{ m}^2$$

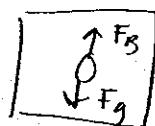
$$\frac{F}{A} = E \frac{\Delta L}{L} \quad \frac{\Delta L}{L} = .03\% = .0003$$

$$F = E (.0003) (.01 \text{ m}^2)$$

$$F = 90 \times 10^9 (.0003) (.01) = 2.7 \times 10^5 \text{ N}$$

$$90 \text{ GPa} = 90 \times 10^9 \text{ Pa}$$

4)



$$|F_B| = |F_g|$$

$$\rho w V_b g = m_b g$$

$$m_b = (\rho \text{ g/cm}^3)(350 \text{ cm}^3)$$

$$= 350 \text{ g}$$

$$= 0.350 \text{ kg}$$

$$W = (0.350 \text{ kg})(9.8 \text{ m/s}^2) = 3.43 \text{ N}$$

appear to be: $12.5 \text{ N} - 3.43 \text{ N}$
 $= 9.07 \text{ N} = 9.1 \text{ N}$

5) $PV = nRT$

here, the volume and pressure will change but
 not n , R , or T so

$$P_1 V_1 = nRT = P_2 V_2$$

$$P_1 V_1 = P_2 V_2$$

$$(750 \times 10^3 \text{ Pa})(1.003 \text{ m}^3) = (100 \times 10^3 \text{ Pa}) V_2$$

$$6) \frac{10\text{kg}}{4\text{kg}} \left| \frac{1\text{kmol}}{1\text{kmol}} \right. = 2.5 \text{ kmol} \Rightarrow V = 1.0\text{m}^3 \quad T = 273 + 20 = 293\text{K}$$

$$PV = nRT$$

$$P = \frac{2500(8.31)(293)}{1\text{m}^3}$$

$$\underline{P = 6.3 \times 10^6 \text{ Pa}}$$

$$7) \quad V_{rms} = \sqrt{\frac{3RT}{M}} \quad R = 8.31 \text{ J/mol} \cdot \text{K} \\ \quad \quad \quad T = 293\text{K} \\ M = 0.028\text{kg/mol}$$

$$\underline{V_{rms} = 475 \text{ m/s}}$$

$$8) \quad \frac{12\text{kg He}}{4\text{kg He}} \left| \frac{1\text{kmol}}{1\text{kmol}} \right. \left| \frac{1000\text{mol}}{1\text{kmol}} \right. \left| \frac{6.02 \times 10^{23} \text{ atoms}}{1\text{mol}} \right. =$$

$$\underline{1.806 \times 10^{37} \text{ atoms}}$$

$$9) \quad \Delta T = 57^{\circ}\text{C}$$

$$\Delta L = \Delta T \alpha = 57(12 \times 10^{-5}) = 6.84 \times 10^{-4}$$
$$= 6.84 \times 10^{-2} \%$$

10) First calculate the energy given out per gram of stream

First cooling of steam ($180 - 100^{\circ}\text{C}$)

$$J = \frac{46 \text{ cal}}{\text{g}^{\circ}\text{C}} (80^{\circ}\text{C}) = 368 \text{ cal/g}$$

Condensation

$$J = 539 \text{ cal/g}$$

Cooling of liquid ($100 - 25^{\circ}\text{C}$)

$$J = \frac{1 \text{ cal}}{\text{g}^{\circ}\text{C}} (15^{\circ}\text{C}) = 15 \text{ cal/g}$$

$$\text{total} = 590.8$$

Now calculate calories needed to heat liquid

$$J = \frac{1 \text{ cal}}{\text{g}^{\circ}\text{C}} (65^{\circ}\text{C}) (500\text{g}) = 32500 \text{ cal}$$

Set these equal and solve for m_{steam}

$$32500 \text{ cal} = m_{steam} (590.8 \text{ J/g})$$

$$m_{steam} = \underline{55 \text{ g}}$$

(1) $W = F \cdot d = mgd = 75(9.8)(8850)$

$$= 6.50 \times 10^6 \text{ J}$$

$$= \frac{6.50 \times 10^6 \text{ J}}{4.193 \text{ kcal}} = 1.55 \times 10^6 \text{ J}$$

$$= 1.55 \times 10^3 \text{ kcal}$$

$$= \underline{1550 \text{ kcal}}$$

(2) let T_c be a variable and set your energy changes equal

$$(95 - T_c)(300 \text{ g})(1 \text{ cal/g}^\circ\text{C}) = (T_c - 20)(500 \text{ g})(1 \text{ cal/g}^\circ\text{C})$$

$$(95 - T_c) = (T_c - 20)\left(\frac{500}{300}\right)$$

$$95 - T_c = (T_c - 20)\left(\frac{5}{3}\right)$$

$$95 - T_c = \frac{5}{3}T_c - \frac{100}{3}$$

$$\frac{385}{3} = \frac{8}{3} T_F$$

$$\underline{T_F = 48.1^\circ C}$$

13)

Stage 1: heat ice (-20 - 0°C)

$$\frac{5 \text{ cal/g}^\circ C}{10^\circ C} = 400 \text{ cal}$$

Stage 2: solid \rightarrow liquid

$$\frac{80 \text{ cal/g}}{10^\circ C} = 3200 \text{ cal}$$

Stage 3: heat liquid (0 - 30°C)

$$\frac{1 \text{ cal/g}}{10^\circ C} = 1200 \text{ cal}$$

$$T_{\text{total}} = 1200 + 3200 + 400 = \underline{4800 \text{ cal}}$$

14) Energy is converted to both internal energy and mechanical energy (movement of piston)

Mechanical energy

$$W = F \cdot d = 10 \text{ kg} (9.8 \text{ m/s}^2) (1.5 \text{ m}) \\ = 49 \text{ J}$$

$$E_{in} = E_{out}$$

$$E_{in} = W + \Delta E_{internal}$$

$$56 = 49 + \Delta E_{internal}$$

$$\Delta E_{internal} = 7 \text{ J}$$

15)

$$\Delta U = Q - W, \text{ where } W = P\Delta V$$

since V is negligible

$$\therefore \Delta U = Q \text{ and}$$

$$Q = mc\Delta T$$

$$Q = 20 \text{ g} \left(2.3 \frac{\text{cal}}{\text{g}^\circ\text{C}} \right) (40^\circ\text{C}) \left(\frac{4.184 \text{ J}}{1 \text{ cal}} \right) \\ = 19246.4 \text{ J} \\ = 1.92 \times 10^4 \text{ J}$$

$$16) \text{ efficiency} = 1 - \frac{T_c}{T_h} \quad T_c = 20 + 273 = 293K$$

$$\cdot 5 = 1 - \frac{293}{T_h}$$

$$\frac{293}{T_h} = .5$$

$$T_h = \frac{293}{.5} = 586 K = 586 - 273 = \underline{313^\circ C}$$

$$17) \text{ efficiency} = \frac{W_{out}}{W_{in}}$$

$$\cdot 3 = \frac{W_{out}}{1000J}$$

$$300J = W_{out}$$

all the energy that doesn't go towards
 W is heat so

$$Q_{out} = W_{in} - W_{out} = \underline{700J}$$

$$18) R\text{-value} \rightarrow \frac{(ft^2 \cdot F^\circ \cdot hr)}{Btu}$$

$$\therefore = \frac{(10ft^2 \cdot 30F^\circ \cdot (1/2hr))}{250 Btu}$$

$$= 1$$

$$19) P_{\text{cond}} = \frac{Q}{t} = kA \frac{T_H - T_C}{L}$$

$$Q = t k A \frac{T_H - T_C}{L}$$

$$Q = (60s)(1.5 \text{ cal/cm-s-}^\circ\text{C})(\pi(12.5\text{ cm})^2) \frac{60^\circ\text{C}}{\text{1 cm}}$$

$$\underline{Q = 8.8 \times 10^6 \text{ cal}}$$

$$20) \text{ thickness}_{\text{cork}} K_{\text{cork}} = \text{thickness}_{\text{brick}} K_{\text{brick}}$$

$$+ 15.0 = 61.3$$

$$+ = \underline{\underline{61.3}} = .36 \text{ in}$$

of table

I used third column because we were
dealing in inches

77777

77777

Instructor: B. Whiting, H.-P. Cheng

PHYSICS DEPARTMENT

PHY 2004

Final Exam

April 26, 2003

Name (print, last first): _____ Signature: _____

*On my honor, I have neither given nor received unauthorized aid on this examination.***YOUR TEST NUMBER IS THE 5-DIGIT NUMBER AT THE TOP OF EACH PAGE.**

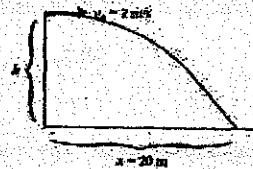
- (1) Code your test number on your answer sheet (use 76-80 for the 5-digit number). Code your name on your answer sheet. **DARKEN CIRCLES COMPLETELY**. Code your student number on your answer sheet.
- (2) Print your name on this sheet and sign it also.
- (3) Do all scratch work anywhere on this exam that you like. At the end of the test, this exam printout is to be turned in. No credit will be given without both answer sheet and printout with scratch work most questions demand.
- (4) Blacken the circle of your intended answer completely, using a #2 pencil or blue or black ink. Do not make any stray marks or the answer sheet may not read properly. If you believe there is no correct answer listed, leave the answer spaces blank.
- (5) The answers are rounded off. Choose the closest to exact.

There is no penalty for guessing.

>>>>>WHEN YOU FINISH <<<<<<
Hand in the answer sheet separately.

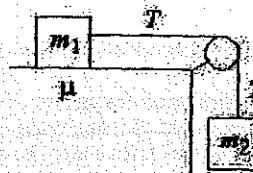
$\rho_{\text{water}} = 1000 \text{ kg/m}^3$	$N_a = 6.022 \times 10^{26} \text{ particles/kmol}$
$\sigma = 5.67 \times 10^{-8} \text{ W/m}^2/\text{K}^4$	$H_V(\text{steam}) = 539 \text{ cal/g}$

1. A ball is thrown at 2 m/s horizontally. It lands 20 m away from starting point. What is h (in m)?



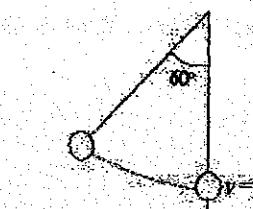
- (1) 490 (2) 75 (3) 3 (4) 56.3 (5) 408

2. Given $m_1 = 12 \text{ kg}$, $m_2 = 20 \text{ kg}$, and $a = 5 \text{ m/s}$, find the coefficient of friction.



- (1) 0.31 (2) 0.52 (3) 2.6 (4) 0.42 (5) 0.26

3. A pendulum is 80 cm long. It is pulled aside to an angle of 60° with the vertical. What is the speed of the pendulum ball as the ball goes through its lowest position? (in m/s)

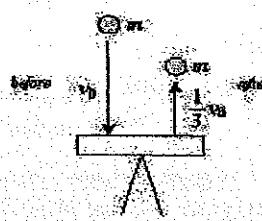


- (1) 2.8 (2) 5.6 (3) 7.8 (4) 0 (5) 13.2

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4. A ball of mass m strikes a scale with a speed v_0 . It rebounds at the speed of $\frac{1}{3}v_0$. What is the impact force on the ball? Assume the contact time is t .



(1) $\frac{4mv_0}{3t}$

(2) $\frac{mv_0}{t}$

(3) $\frac{2mv_0}{3t}$

(4) v_0t

(5) 0

5. How many grams of hot steam at 130°C are needed to heat 1000 g of water at 50°C to 90°C ? ($C_{\text{water}} = 1 \text{ cal/g}/^\circ\text{C}$, $C_{\text{steam}} = 0.46 \text{ cal/g}/^\circ\text{C}$)

(1) 71.1

(2) 36.2

(3) 326.3

(4) 0.5

(5) 13.8

6. The temperature of the sun's surface is 5500 K. How much heat does it radiate in a day assuming the sun is a blackbody (in J)? ($R_{\text{sun}} = 7 \times 10^8 \text{ m}$)

(1) $2.8 \times 10^{31} \text{ J}$

(2) $3.6 \times 10^{20} \text{ J}$

(3) 560.2

(4) $4.3 \times 10^{50} \text{ J}$

(5) $3.9 \times 10^6 \text{ J}$

7. A 0.5 kg mass vibrates with amplitude 5 cm at the end of a spring whose spring constant is 25 N/m. Find the speed of the mass when its displacement is 4 cm (in m/s).

(1) 0.21

(2) 1.4

(3) 366

(4) 2.1

(5) 3.6

8. A 50 cm length of straight pipe is attached to a car's muffler. This tail pipe acts as a tube open on one end but closed on the other. Assume the speed of sound is 360 m/s in the pipe. Find the frequency of its first overtone (Hz) (hint: the second lowest frequency).

(1) 540

(2) 300

(3) 4060

(4) 15

(5) 70

9. Which of the following statements is incorrect?

(1) The fundamental frequency of a string or pipe depends on external force.

(2) Waves can pass through each other when they meet.

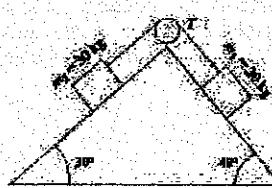
(3) The higher the frequency, the shorter the period.

(4) The speed of a wave is given by a product of the frequency and wavelength.

(5) A pipe with one end open has a lower fundamental frequency than a closed pipe of the same length.

10. Assume zero friction. What is the acceleration of the system?

(m/s²)



(1) 0.42 to the left

(2) 0.33 to the right

(3) 0 static

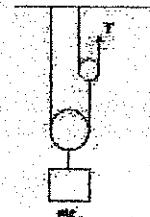
(4) 3.2 to the left

(5) 1.6 to the right

11. Assume two identical masses of mass m undergo elastic collision in a straight line. If $v_1 = 5 \text{ m/s}$ and $v_2 = 0$ initially, find v_2 after the collision.

(1) 5 m/s (2) -5 m/s (3) 0 (4) +2.5 m/s (5) -2.5 m/s

12. What is the tension T in order to keep the system in equilibrium?

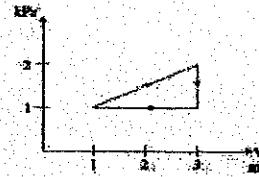


(1) $\frac{mg}{4}$ (2) mg (3) $\frac{mg}{2}$ (4) $\frac{mg}{3}$ (5) $\frac{mg}{5}$

13. A solid piece of aluminum "weighs" 57.6 g in air and 26.5 g when submerged in a liquid. What is the mass density of the liquid? (kg/m^3 ; $\rho_{\text{aluminum}} = 2700 \text{ kg/m}^3$)

(1) 1460 (2) 2040 (3) 980 (4) 208 (5) 15000

14. Estimate the work done when one cycle is completed (in J).



(1) 1000 (2) -100 (3) 560 (4) 1 (5) 0

15. Add together the following two vectors. The first has one component of magnitude 70 in the negative x direction and another component of magnitude 90 in the positive y direction. The second vector has a magnitude of 120 in a direction 230° counterclockwise from the positive x axis.

(1) 147 at 181° (2) 182 at 88° (3) 25.4 at 30° (4) 233 at 134° (5) 280 at 230°

16. A string holds a 3.0-kg object in a horizontal circle of 60-cm radius while the object moves at a rate of 1.20 rev/s. What is the tension in the string?

(1) 102 N (2) 31.6 N (3) 5.6 N (4) 10.1 N (5) 3.6 N

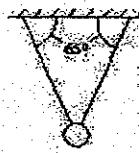
17. The acceleration due to gravity on the moon is about 1.61 m/s^2 . What will be the period of a 200-cm-long pendulum on the moon (in seconds)?

(1) 7.0 (2) 1.1 (3) 5.6 (4) 0.9 (5) 4.5

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18. Find the tension in each cord shown if the object weighs 50 N.



- (1) 27.6 N (2) 55.1 N (3) 13.7 N (4) 22.5 N (5) 45.4 N

19. A certain mass undergoes simple harmonic motion at the end of a spring. The period of the motion is 2.10 s. The mass oscillates back and forth through a total distance of 20 cm. Find the maximum speed of the mass.

- (1) 0.3 m/s (2) 20 m/s (3) 2.1 m/s (4) 0.03 m/s (5) 70 m/s

20. A heavy weight hangs at the end of a 140-m cable. A worker at the top of the cable notices that when he strikes the top of the cable sideways, the pulse hits the weight after a time of 4.0 s. With about what frequency must he vibrate the top end if the rope is to resonate in its fundamental?

- (1) 0.125 Hz (2) 17.5 Hz (3) 4.4 Hz (4) 557 Hz (5) 2.0 Hz

$$1. \quad x = x_0 + v_0 t + \frac{1}{2} a t^2 \quad y = y_0 + v_0 t + \frac{1}{2} a t^2$$

$$x = 0 + 2 \frac{m}{s} \cdot t \quad a = -9.8 \text{ m/s}^2$$

$$x_{\text{final}} = 20 \text{ m} = 2 \frac{m}{s} \cdot t \quad y = h + 0 - \frac{1}{2} \cdot 9.8 \frac{m}{s^2} \cdot t^2$$

$$t_{\text{final}} = 10 \text{ seconds} \quad y = h - 4.9 \left(\frac{m}{s^2} \right) \cdot t^2$$

$$y_{\text{final}} = h - 4.9 \left(\frac{m}{s^2} \right) (t_{\text{final}})^2$$

since the ball is hitting the ground, $y_{\text{final}} = 0$

$$0 = h - 4.9 \left(\frac{m}{s^2} \right) (10 \text{ s})^2$$

$$0 = h - 4.9 \left(\frac{m}{s^2} \right) \cdot 100 \text{ s}^2$$

$$h = 490 \text{ meters}$$

$$2. \quad F_{fr} = \mu F_{\text{Normal}}$$

Forces on mass 1

Forces on mass 2

Forces on mass 1

$$F_{fr} \rightarrow \boxed{m_1} \uparrow F_N \quad \downarrow mg \quad T \rightarrow$$

$$T - F_{fr} = m a$$

$$T - \mu F_{\text{Normal}} = 12 \text{ kg} (5 \frac{\text{m}}{\text{s}^2})$$

$$T - \mu m g = 12 \text{ kg} (5 \frac{\text{m}}{\text{s}^2})$$

$$T - \mu (12 \text{ kg}) \cdot 9.8 \text{ m/sec}^2 = 12 \text{ kg} (5 \frac{\text{m}}{\text{s}^2})$$

Forces on mass 2

$$-F_g + T = -m a \quad (\text{a is negative since it is accelerating downwards})$$

$$-F_g + T = -20 \text{ kg} (5 \frac{\text{m}}{\text{s}^2})$$

$$-9.8 (\text{m/s}^2) \cdot 20 \text{ kg} + T = -20 \text{ kg} (5 \frac{\text{m}}{\text{s}^2})$$

Equation 1

$$T - \mu(12\text{kg}) \cdot 9.8 \text{ m/s}^2 = 12\text{kg} (5 \text{ m/s}^2)$$

$$T = 117.6 \text{ N} \left(\frac{\text{kgm}}{\text{s}^2}\right) + 60 \text{ kg m/s}^2$$

Equation 2

$$-9.8 \text{ (m/s}^2) \cdot 20\text{kg} + T = -20\text{kg}(5 \frac{\text{m}}{\text{s}^2})$$

$$T = 96 \frac{\text{kgm}}{\text{s}^2}$$

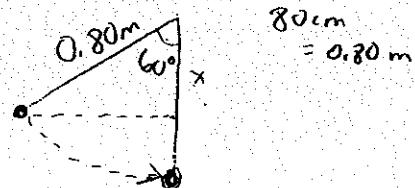
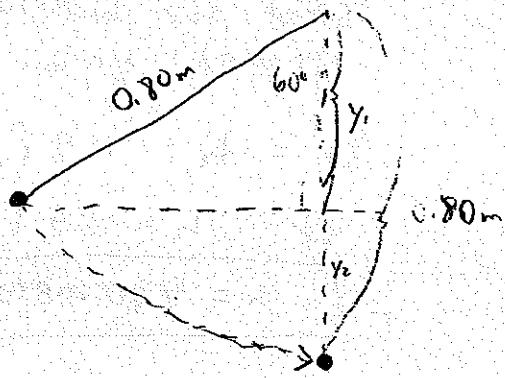
Substitute T into

$$96 \frac{\text{kgm}}{\text{s}^2} = 117.6 \text{ N} \left(\frac{\text{kgm}}{\text{s}^2}\right) + 60 \frac{\text{kgm}}{\text{s}^2}$$

$$\mu = 0.306 \approx \boxed{0.31}$$

Equation 1

3.



$$y_1 = 0.80 \cos 60^\circ$$

$$y_1 = 0.4 \text{ m}$$

$$y_2 = 0.80 \text{ m} - y_1$$

$$y_2 = 0.4 \text{ m}$$

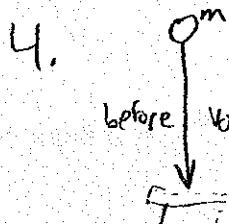
Since the pendulum is initially at rest, all of its energy is potential energy.

The potential energy is given by mgh , where h is y_2 in this case, the potential energy is

$$\begin{aligned} E &= mgh \\ &= m(9.8 \text{ m/s}^2) \times 0.4 \text{ m} \\ &= 3.92 \text{ m} \left(\frac{\text{m}^2}{\text{s}^2}\right) \end{aligned}$$

At the bottom of the swing, all of the potential energy is converted to kinetic. The Kinetic Energy is given by

$$E = 3.92 \text{ m} \left(\frac{\text{m}^2}{\text{s}^2}\right) = \frac{1}{2}mv^2 \quad v = \sqrt{7.84 \frac{\text{m}^2}{\text{s}^2}} = \boxed{2.8 \text{ m/s}}$$



$$F = m \cdot \frac{\Delta v}{\Delta t}$$

$$V_i = -V_0 \quad V_f = +\frac{1}{3} V_0$$

$$\Delta v = V_f - V_i = \frac{4}{3} V_0$$

$$F = \boxed{\frac{4mV_0}{3t}}$$

5. The steam follows this process: $130^\circ\text{C} \rightarrow 100^\circ\text{C} \xrightarrow{\text{Conversion to water}} 100^\circ\text{C} \rightarrow 90^\circ\text{C}$
 The water follows this process: $50^\circ\text{C} \rightarrow 90^\circ\text{C}$
 The heat which flows out of the steam is used to heat the water.

$$\text{Steam } 130^\circ\text{C} \rightarrow 100^\circ\text{C} \quad mc\Delta T = Q_1$$

$$\underline{\text{Step 1}} \quad X \text{ grams} \times (0.46 \frac{\text{cal}}{\text{g}^\circ\text{C}}) \times (130^\circ\text{C} - 100^\circ\text{C}) = Q_1$$

$$13.8X \text{ (cal)} = Q_1$$

$$100^\circ\text{C} \rightarrow 100^\circ\text{C} \quad \underline{\text{Step 2}}$$

$$H_v \cdot m = Q_2$$

$$539 \frac{\text{cal}}{\text{g}} \times X(\text{g}) = Q_2$$

$$100^\circ\text{C} \rightarrow 90^\circ\text{C} \quad \underline{\text{Step 3}}$$

$$mc\Delta t = Q_3$$

$$X(\text{g}) \cdot 1 \frac{\text{cal}}{\text{g}^\circ\text{C}} \cdot (100^\circ\text{C} - 90^\circ\text{C}) = Q_3$$

$$10X \text{ (cal)} = Q_3$$

$$\text{water: } mc\Delta t = Q_1 + Q_2 + Q_3$$

$$1000 \text{ g} \times 1 \frac{\text{cal}}{\text{g}^\circ\text{C}} \times (90^\circ\text{C} - 50^\circ\text{C}) = Q_1 + Q_2 + Q_3$$

$$40,000 \text{ cal} = 13.8X + 539X + 10X$$

$$40,006 \text{ cal} = 562.8X$$

$$X = 71.07 \text{ g} \approx \boxed{71.1 \text{ g}}$$

6. $P = \sigma AT^4$ Surface Area for a sphere = $4\pi R^2$

$$P = 5.67 \times 10^{-8} \text{ W/m}^2 \text{ K}^4 \times 4\pi (7 \times 10^8 \text{ m})^2 (5500 \text{ K})^4$$

$$P = 3.195 \times 10^{26} \text{ W} \quad 1 \text{ W} = \frac{1 \text{ J}}{1 \text{ sec}}$$

$$3.195 \times 10^{26} \frac{\text{J}}{\text{sec}} \times 1 \text{ Day} = Q_{\text{total}}$$

$$3.195 \times 10^{26} \frac{\text{J}}{\text{sec}} \times 86400 \frac{\text{sec}}{\text{day}}$$

$$Q = 2.76 \times 10^{31} \text{ J} \approx 2.8 \times 10^{31} \text{ J}$$

7. When the spring is at its full extension of 5cm, all of its energy is potential energy

$$E = \frac{1}{2} kx^2 \quad k = 25 \frac{\text{N}}{\text{m}} \quad x = 0.05 \text{ m}$$

$$E_{\text{total}} = \frac{1}{2} (25 \frac{\text{N}}{\text{m}}) (0.05 \text{ m})^2$$

$$E_{\text{total}} = 0.03125 \text{ N}\cdot\text{m} = 0.03125 \text{ J}$$

At an extension of 4cm, the potential energy is given by $U = \frac{1}{2} kx^2$, and the Kinetic Energy is $E_{\text{total}} - U$

$$U = \frac{1}{2} (25 \frac{\text{N}}{\text{m}}) (0.04 \text{ m})^2 \\ = 0.02 \text{ J}$$

$$KE = E_{\text{total}} - U = 0.03125 \text{ J} - 0.02 \text{ J} = 0.01125 \text{ J}$$

$$KE = \frac{1}{2} mv^2 = 0.01125 \text{ J} \quad m = 0.5 \text{ kg}$$

$$V = 0.21 \text{ m/s}$$

8. For a closed tube, the resonant frequencies are given by

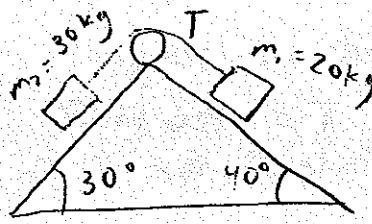
$$V_n = n \frac{V}{4L}, n = 1, 3, 5, \dots$$

The speed of sound, V , in this case is 360 m/s, and we are looking for the second resonant frequency ($n=3$)

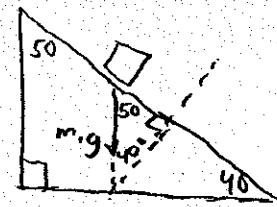
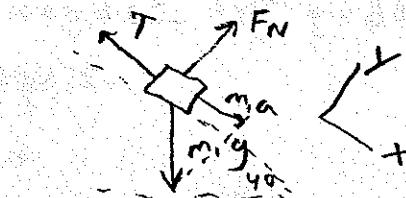
$$V_n = 3 \times \frac{360 \text{ m/s}}{4 \times (0.5 \text{ m})} = 540 \frac{1}{3} = 1540 \text{ Hz}$$

9. The fundamental frequency of a string or pipe depends only on length, not external force.
All other statements are correct.

10.



Forces acting on m_1



Based on my choice for the coordinate axes, the forces in the y axis cancel, and I only have to worry about forces in the x direction.

The force of gravity acting in the x direction is $m_1 g \sin 40^\circ$

$$m_1 g \sin 40^\circ - T = m_1 a$$

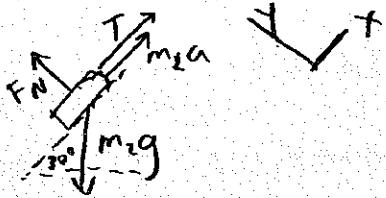
$$20 \text{ kg} \times 9.8 \frac{\text{m}}{\text{s}^2} \times .643 - T = 20 \text{ kg} \cdot a$$

$$125.99 \text{ kg} \frac{\text{m}}{\text{s}^2} - T = 20 \text{ kg} \cdot a$$

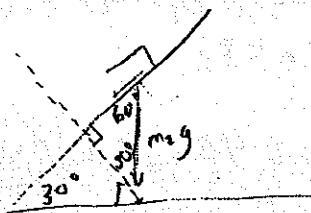
Eq. ①

10 cont'd

Forces acting on mass 2



Based on my choice
of the coordinate
axes, the forces in the
y direction sum to zero



Force of gravity acting in x direction is

$m_2 g \sin 30^\circ$, and it acts in the left direction, so it is negative

$$T = m_2 g \sin 30^\circ = m_2 a$$

$$T = 30 \text{ kg} \times 9.8 \text{ m/s}^2 \times 0.5 = 30 \text{ kg} \cdot \text{m/s}^2$$

$$[E9.2] \quad T - 147 \text{ kg m/s}^2 = 30 \text{ kg} \times a$$

From last page Eq. 1

$$126 \text{ kg} \frac{m}{s^2} - T = 20 \text{ kg} \cdot a$$

$$T = 126 \text{ kg m/s}^2 - 20 \text{ kg m}$$

Substitute \bar{v}_T for T in Eq. 2

$$126 \text{ kg m/s}^2 - 20 \text{ kg m/s} = 147 \text{ kg m/s}^2 = 30 \text{ kg m/s}$$

$$-21 \text{ kg m/s} = 50 \text{ kg x a}$$

$$a = -42 \text{ m/s}^2$$

Since a is negative, it is accelerating to the left at -0.42 m/s^2

$$\text{II. } m_1 = m \quad m_2 = m \\ V_1 = 5 \text{ m/s} \quad V_2 = 0 \text{ m/s}$$

Conservation of Energy

$$\frac{1}{2} \rho V_1^2 + \frac{1}{2} \rho V_2^2 = \frac{3}{2} \rho V_r^2.$$

$$\frac{1}{2} (5^{\circ}) + \frac{1}{2} (0^{\circ}) = \frac{1}{2} v_1^2 + \frac{1}{2} v_2^2$$

$$\text{Eq. 2: } 12.5 = \frac{1}{2} V_1^2 + \frac{1}{2} V_2^2 \text{ final}$$

Conservation of linear momentum

$$mV_1 + mV_2 = mV_1 + mV_2$$

$$5 \frac{m}{s} \cdot g x = y x v_1 + y v_1 v_2$$

$$E.G. 1: \quad 5 \frac{m}{s} = v_1 + v_2$$

$$Eq.1 \quad 5 \text{ m/s} = v_1 + v_2$$

$$v_1 = 5 \text{ m/s} - v_2$$

Substitute into Eqn. 2

$$Eq.2 \quad 12.5 = \frac{1}{2} v_1^2 + \frac{1}{2} v_2^2$$

$$12.5 = \frac{1}{2} (5 \text{ m/s} - v_2)^2 + \frac{1}{2} v_2^2$$

$$12.5 = \frac{1}{2} v_2^2 - 5 \cdot \frac{v_2}{2} + 12.5 \text{ m/s}^2 + \frac{1}{2} v_2^2$$

$$v_2^2 = 5 v_2$$

$$v_2^2 - 5 v_2 + 0 = 0$$

$$v_2(v_2 - 5) = 0$$

$$v_2 = 0 \text{ m/s} \text{ or } v_2 = 5 \text{ m/s}$$

Case 1

$$v_1 = v_2 - 5 \text{ m/s}$$

$$\text{if } v_2 = 0 \text{ m/s} \quad \text{if } v_2 = 5 \text{ m/s}$$

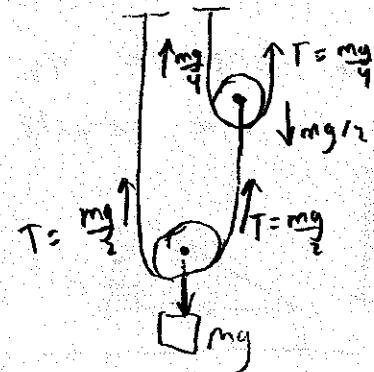
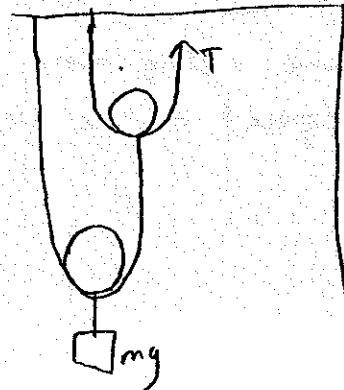
$$v_1 = 5 \text{ m/s}$$

Case 2

$$v_1 = 0 \text{ m/s}$$

In order for case 1 to be true, the first mass would have to travel through the second. Since this is impossible, case 2 is correct, and
 $(v_2 = 5 \text{ m/s})$

12.



The tension in any string is constant

In order to stay in equilibrium, T must be $\frac{mg}{4}$.

13.]

57.6 g in air 26.5 g in liquid

$$\rho_{\text{aluminum}} = 2700 \frac{\text{kg}}{\text{m}^3}$$

Volume of aluminum present : $\frac{\text{mass}}{\text{density}} = \text{Volume}$

$$\frac{0.576 \text{ kg}}{2700 \text{ kg/m}^3} = 2.133 \times 10^{-5} \text{ m}^3$$

Buoyant force is volume displaced \times density of liquid \times gravity

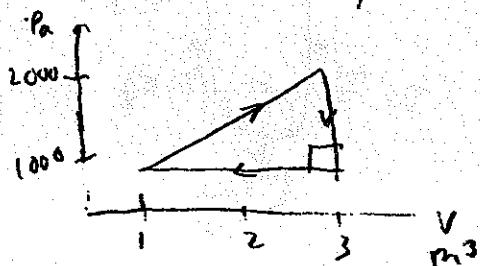
$$2.133 \times 10^{-5} \text{ m}^3 \times \rho \times 9.8 \text{ m/s}^2 = mg, \text{ where } m \\ \text{is the mass in air - mass in liquid}$$

$$2.133 \times 10^{-5} \text{ m}^3 \times \rho = (57.6 - 26.5) \text{ g}$$

$$\rho = 1458.00 \text{ g/m}^3 \\ (\rho \approx 1460 \text{ kg/m}^3)$$

14.]

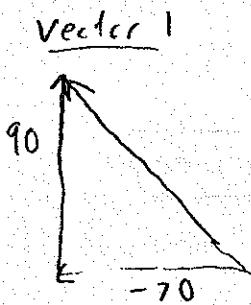
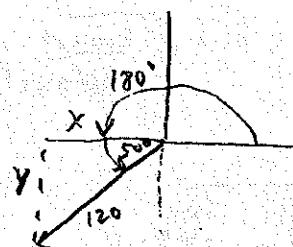
In a pressure vs. volume diagram, the work done in one cycle is equal to the area enclosed.



Area of triangle $\frac{1}{2} \text{ base} \times \text{height}$

$$= \frac{1}{2} (3-1) \times (2000-1000) = 1000$$

15.

Vector 2

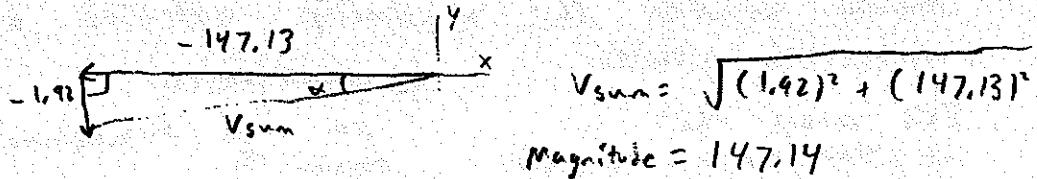
The x component of Vector 2 is
 $-120 \cos 50 = -77.13$

The y component of Vector 2 is
 $-120 \sin 50 = -91.92$

Add components of vectors to find the resulting vector

X components: $-70 - 77.13 = -147.13$

Y components: $90 - 91.92 = -1.92$



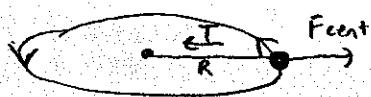
$$\alpha = \tan^{-1} \left(\frac{1.92}{147.13} \right)$$

$$\alpha = 0.75^\circ$$

Total angle = $180^\circ + 0.75^\circ \approx 181^\circ$

Magnitude = 147.14

16.



$$F = \frac{mv^2}{R}$$

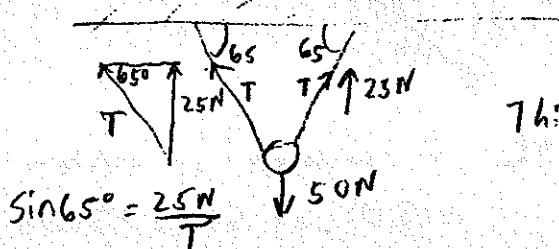
$$V = 1.2 \frac{\text{rev}}{\text{sec}} \times 2\pi R \frac{\text{meter}}{\text{rev}} = 4.52 \text{ m/s}$$

$$T = \frac{mv^2}{R} = 102.3 \text{ N}$$

17. $T = 2\pi \sqrt{\frac{L}{g}}$

$$T = 2\pi \sqrt{\frac{2.00\text{m}}{9.81\text{m/s}^2}} = 7.0\text{ sec}$$

18.



This means that the total force up is 50N, or 25N for each

$$T = \frac{25\text{N}}{\sin 65^\circ} = 27.6\text{N}$$

19. $T = 2.10\text{s}$ Total distance = $20\text{cm} = 0.2\text{m}$

$$U = \frac{1}{2}kx^2 \quad KE = \frac{1}{2}mv^2$$

The spring has an equilibrium position that is midway between the maximally extended and maximally contracted states.

This means that at either 0m or 0.2m, the spring is composed of solely Potential Energy and $x = 0.1\text{m}$

Eqn. 1 $E_{\text{pot}} = U = \frac{1}{2}k(0.1)^2 = 0.005k$

$$E_{\text{tot}} = 0.005 \times 8.95\text{J} = 0.045\text{J}$$

When velocity is maximized, there is no Potential energy, so

$$E_{\text{kin}} = KE = \frac{1}{2}mv^2 = 0.045\text{J}$$

$$v^2 = 2.895$$

$v = 0.30\text{ m/s}$

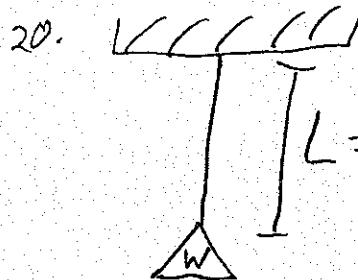
Maximal extension
Position
Contracted equilibrium

$$T = 2\pi \sqrt{\frac{m}{k}}$$

$$\left(\frac{T}{2\pi}\right)^2 = \frac{m}{k}$$

$$k = \frac{m \cdot 4\pi^2}{T^2} \quad k = 8.95\text{N/m}$$

Substitute k into eqn. 1



time for wave to hit
weight (Δt) is 4.05

$$\text{hence } v = \frac{L}{\Delta t} = \frac{140\text{cm}}{4.05} = 35 \frac{\text{cm}}{\text{s}}$$

recall:

$$f_n = n \frac{v}{2L} \quad n=1, 2, 3, \dots$$

$$\text{Fundamental frequency} \Rightarrow n=1 \quad \text{hence } f_1 = \frac{v}{2L} = \frac{25\cancel{\text{cm}}}{(2 \cdot 14\text{cm})}$$

$$= 125 \text{ s}^{-1} = 125 \text{ Hz}$$

77777

77777

Instructor: B. Whiting, H.-P. Cheng

PHYSICS DEPARTMENT

PHY 2004

Exam 2

March 3, 2003

Name (print, last first):

Signature:

On my honor, I have neither given nor received unauthorized aid on this examination.

YOUR TEST NUMBER IS THE 5-DIGIT NUMBER AT THE TOP OF EACH PAGE.

DIRECTIONS

- (1) Code your test number on your answer sheet (use 76-80 for the 5-digit number). Code your name on your answer sheet. DARKEN CIRCLES COMPLETELY. Code your student number on your answer sheet.

(2) Print your name on this sheet and sign it also.

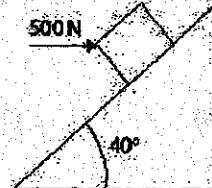
(3) Do all scratch work anywhere on this exam that you like. At the end of the test, this exam printout is to be turned in. No credit will be given without both answer sheet and printout with scratch work most questions demand.

(4) Blacken the circle of your intended answer completely, using a #2 pencil or blue or black ink. Do not make any stray marks or the answer sheet may not read properly.

(5) The answers are rounded off. Choose the closest to exact. There is no penalty for guessing.

>>>>>>WHEN YOU FINISH <<<<<<

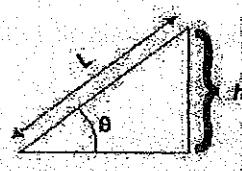
Hand in the answer sheet separately.



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5. An incline is a simple machine to lift a heavy object. What is the IMA of the incline of angle θ ?

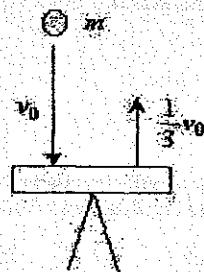


- (1) $\frac{1}{\sin \theta}$ (2) $\sin \theta$ (3) 1 (4) $\frac{L}{\sin \theta}$ (5) $L \cdot h$

6. For a certain pulley system, a load of 600 N can be lifted 3 cm by an input force of 100 N pulling through a distance of 24 cm. What is the efficiency of the system?

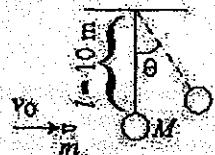
- (1) 0.75 (2) 1.25 (3) 1 (4) 0.5 (5) 5.033

7. A ball of mass m falls on a scale with a speed v_0 . It rebounds at the speed of $\frac{1}{3}v_0$. What is the impact force on the ball? Assume the contact time is t .



- (1) $\frac{4}{3} \frac{mv_0}{t}$ (2) $\frac{mv_0}{t}$ (3) $\frac{2}{3} \frac{mv_0}{t}$ (4) $v_0 t$ (5) 0

8. A bullet of mass $m = 100$ g with initial velocity $v_0 = 200$ m/s collides with a pendulum ball of mass $M = 3$ kg. It sticks to the ball after the collision. What is the angle of the pendulum with the vertical at the highest position? (in degrees)



- (1) 38.0 (2) 82.0 (3) 5.0 (4) 45.2 (5) 90

9. A roller coaster has a loop-the-loop circular position in its track. Assuming the curved path has a radius of 8.0 m, how fast must the cart be moving at the top of its track if the passengers in the cart are to be just on the verge of falling out? (in m/s)

- (1) 8.85 (2) 0 (3) 1.03 (4) 120.0 (5) 12.6

10. How strong must a string be if a 2 kg mass is to be swung from it in a horizontal circle of 1 m radius at 1 rev/s? (in N) (Calculate the force on the string.)

- (1) 79.0 (2) 10.3 (3) 0 (4) 120.1 (5) 500.3

Exam 2 2003 PHY 2004

1)

constant speed so the only force is the force to overcome friction

$$F = \mu_k mg = .0015(60)(9.8) = .882 \text{ N}$$

$$W = F \cdot d = .882 \text{ N} (1000 \text{ m}) = \underline{882 \text{ J}}$$

2)

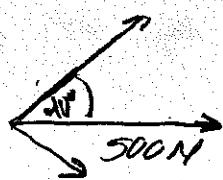
Energy conservation is the key here
not projectile motion!

$$\mu_k g h = \frac{1}{2} \mu v^2$$

$$gh = \frac{1}{2} v^2$$

$$v = \sqrt{2gh} = \sqrt{2(9.8)(146)} = \underline{30 \text{ m/s}}$$

3)

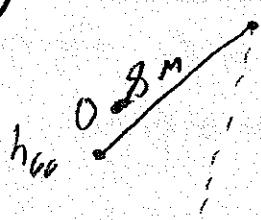


the force to look at here
is the force parallel to
the plane of motion

$$\text{so } F = 500 \cos 40^\circ = 383 \text{ N}$$

$$W = Fd = 383(2) = \underline{766 \text{ J}}$$

4)



The length of the pendulum is constant but the height of the ball changes. By looking

at change in height change in potential energy can be found
that change in kinetic energy is found.

$$h_{60^\circ} = l \cos 60^\circ = 0.4m$$

$$h_0 = l \cos 0^\circ = 0.8m$$

$$\Delta h = 0.4m$$

$$mg \Delta h = \frac{1}{2}mv^2$$

$$2(9.8(0.4)) = v^2$$

$$v = 2.8 \text{ m/s}$$

5) F to lift object straight up at constant v

$$F = W = mg$$

F to lift object w/ramp at constant v

$$F = W \sin \theta = mg \sin \theta$$

$$TMA = \frac{mg}{mg \sin \theta} = \frac{1}{\sin \theta}$$

$$6) W_{\text{put in}} = F \cdot d = 100(24) = 2400 \text{ J}$$

$$W_{\text{out}} = F \cdot d = 600(0.3) = 180 \text{ J}$$

$$\text{efficiency} = \frac{W_{\text{out}}}{W_{\text{in}}} = \frac{180}{2400} = \frac{3}{40} = 0.25$$

7)

$$\Delta p = J = F \Delta t \checkmark \text{time}$$

\uparrow charge
in linear momentum

\uparrow impact force

$$\Delta p = mv_0 + \frac{1}{2}mv_0 = \frac{4}{3}mv_0$$

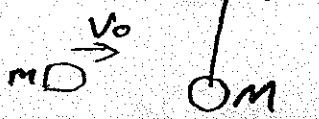
$$\Delta t = t$$

$$\frac{4}{3}mv_0 = Ft$$

$$F = \frac{4mv_0}{3t}$$

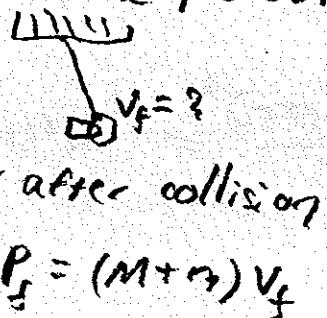
8)

Use momentum conservation to find the initial speed of the pendulum



before collision

$$P_i = mv_i$$



after collision

$$P_f = (m+m)v_f$$

here

$$P_i = P_f \Rightarrow V_f = \frac{m}{(M+m)} V_i = \frac{0.1 \text{ kg}}{(3 \text{ kg} + 0.1)} (200 \frac{\text{m}}{\text{s}}) \quad l=10 \text{ m} \quad m=100 \text{ g} \rightarrow 0.1 \text{ kg}$$
$$M=3 \text{ kg}$$

$= 6.45 \frac{\text{m}}{\text{s}}$ ← lets call this V , Now use conservation of energy

Diagram

$l/2$

$l/2 - h$

$v_f = 0$

at height
page

$$\text{hence } \frac{1}{2} (M+m) V^2 = (m+m) g h$$

$$h = \frac{V^2}{2g} = \frac{(6.45 \frac{\text{m}}{\text{s}})^2}{2(9.81 \frac{\text{m}}{\text{s}})} = 2.12 \text{ m}$$

I.t. i> deduces from the picture that $\theta = \cos^{-1}\left(\frac{l-h}{l}\right) = \cos^{-1}\left(\frac{10-2.12}{10}\right)$

$$= \boxed{38^\circ}$$

- 9) here the passengers should feel an equal force from gravity and centripetal force.

$$mg = \frac{mv^2}{r} \quad v^2 = gr \quad v = \sqrt{gr} = \sqrt{9.81(2)}$$

$$\underline{v = 8.85 \text{ m/s}}$$

- 10) the force on the string is just the centripetal force

$$F = \frac{mv^2}{r} \quad v = 1 \text{ rev/s} = 2\pi r/\text{s}$$

$$F = \frac{m(2\pi r)^2}{r} = m4\pi^2 r = 2(4\pi^2)1$$

$$= 8\pi^2 = \underline{79 \text{ N}}$$

PHYSICS DEPARTMENT

PHY2004

Exam #1

Sept. 23, 1996

Stanton

NAME

(PRINT) -----

(SIGNATURE) -----

You must sign the green answer sheet and this test indicating your compliance with the honor code.

DIRECTIONS

- (1) Code your test number on your green answer sheet (use 76-80 for the 5-digit number). Code your name and student number on your answer sheet. Darken circles completely (errors can occur if too light).
- (2) Print your name on this sheet and sign it also.
- (3) Do all scratch work on this exam to the right of the questions, and anywhere else on this exam. At the end of the test, this exam printout is to be turned in. No credit will be given without both the answer sheet and printout, with the scratch work which most questions demand of anyone.
- (4) Work the questions in any order. Incorrect answers are not taken into account in any way; you may guess at answers you don't know if you feel that a correct answer is listed. Guessing on all questions will most likely result in failure.
- (5) Black the circle of your intended answer completely, using a number 2 pencil on the answer sheet. Do not make any stray marks or the answer sheet may not read properly.
- (6) As an aid to the examiner (and yourself) in the case of poorly marked answer sheets, please circle your selected answer on the examination sheet.
- (7) Good luck!!!!

>>>>> BEFORE YOU FINISH <<<<<

Fold the computer print out so your name is on top, include any figure sheet inside the print out. Hand in the green answer sheet separately.

If none of the answers are correct, please leave the answer sheet blank. It is not our intention to omit the right answer, but in case of a mistake please leave the answer sheet blank.

Use the following:

$$g = 9.8 \text{ m/s}^2 = 32.2 \text{ ft/s}^2$$

$$\text{mass of earth} = 6.0 \times 10^{24} \text{ kg}$$

$$\text{radius of earth} = 6.4 \times 10^3 \text{ km}$$

$$1 \text{ mile} = 5280 \text{ ft}$$

$$G = 6.67 \times 10^{-11} \text{ N-m}^2/\text{kg}^2$$

1. Vector A is 5 units long and directed along the positive y-axis. Vector B is 7 units long and directed along the negative x-axis. Vector C is 10 units long and directed along the negative y-axis. What is the MAGNITUDE of the vector, A+B-2C ?
 1. 26.0 units
 2. 8.0 units
 3. 16.6 units
 4. 8.6 units
 5. 2.0 units
2. Vector A is 20 m long in the +x direction. Vector B is 10 m long in the +y direction. What angle does the vector A-

2B make with respect to the +x direction (measured counterclockwise, as is the usual convention)?

1. 315°
 2. 45°
 3. 27°
 4. 333°
 5. 225°
3. Vector A has magnitude 15 km and is in a direction 150° counterclockwise from the +x axis. What is the value for the x-component of A in km?
1. -13
 2. 13
 3. 7.5
 4. -7.5
 5. -9.6
4. * A car is moving due north at a speed of 10m/sec. It enters a curve and ends up heading due west at a speed of 10m/sec. The change in velocity vector, $v_f - v_i$, is in the _____ direction.
1. SW
 2. NW
 3. NE
 4. SE
 5. S
5. David Letterman stands on the roof of the CBS studio in New York. He throws a watermelon with an intial velocity in the +y-direction (upwards) of 15 feet/sec. It a takes 7.5 seconds for the watermelon to smash on the pavement below. How tall, in feet, is the CBS studio? (neglect any air friction).
1. 793
 2. 1020
 3. 906
 4. 388
 5. 163
6. A car is travelling down the road at a speed of 75 km/hr. A deer darts in front of the car 200 m ahead. Assuming the driver applies the brakes instantaneously, what is the minimum rate of deceleration in m/sec^2 so that the driver stops before hitting the deer?
1. 1.1
 2. 14.1
 3. 2.2
 4. 7.1
 5. 9.8
7. * A canonball is fired at a 37° degree angle. If the range of the canonball is 1200m, then what is the intial velocity

in m/sec that the cannonball must have? (Neglect any air friction).

1. 111
 2. 77
 3. 1.2×10^4
 4. 89
 5. 67
8. A police car travelling along the highway at 60 miles/hr notices someone speeding. The police car uniformly changes its velocity from 60 miles/hr to 90 miles/hr in 5 seconds. What is the acceleration of the police car, in ft/sec² during this time?
1. 8.8
 2. 6.0
 3. 18.0
 4. 26.4
 5. 12.0
9. The mass of Planet X (newly discovered) is 6 times the mass of Earth and its radius is 3 times the radius of Earth. What is the acceleration due to gravity, g_x , at the surface of Planet X in m/sec²?
1. 6.5
 2. 14.7
 3. 4.9
 4. 19.6
 5. 6.9
10. Figure 1 shows a mass of 20 kg hanging from a rope inside an elevator car. If the tension in the rope is 174 Newtons, then what is the magnitude (in m/sec²) and direction of the acceleration of the elevator car?
1. 1.1 down
 2. 1.1 up
 3. 0
 4. 21 up
 5. 21 down
11. A 2000 kg truck is moving at 20 m/s. It uniformly slows to a stop in a distance of 100 m. What was the force, in Newton, of deceleration during this time?
1. 4000
 2. 800
 3. 8000
 4. 200
 5. 400
12. The two blocks shown in figure 2, each have a mass of 1.6 kg. The tension in the cord at the left is 5.0 N. What is the tension in the cord connecting them in N? Neglect friction with the table.

- 1. 2.5
 - 2. 5.0
 - 3. 0
 - 4. 15.7
 - 5. 8.0
13. An ice skater with mass 55 kg, has an initial velocity of 5 m/sec. If it takes 10 seconds for the skater to come to rest and the only force acting on the skater is friction, then what is the coefficient of friction between the ice skates and ice?
- 1. 0.05
 - 2. 0.1
 - 3. 0.02
 - 4. 0.5
 - 5. 0.01
14. A box of mass 10 kg slides down an inclined plane with angle 37° (see figure 3). If the acceleration is 3.2 m/s^2 down the plane, then what is the frictional force in Newtons?
- 1. 27
 - 2. 78
 - 3. 32
 - 4. 46
 - 5. 66
15. * A 30 kg sled is being pushed on ice as shown in figure 4. If the handle makes an angle of 40° with the ice, and the coefficient of friction is 0.1, then how much force (in Newtons) must be directed along the handle so the sled moves at a constant speed of 5 m/s?
- 1. 42
 - 2. 35
 - 3. 52
 - 4. 38
 - 5. 46
16. How large a force (in newtons) does it take to push a 25 kg box up a 25° incline at a constant velocity if the coefficient of friction between the box and incline is 0.6?
- 1. 237
 - 2. 284
 - 3. 104
 - 4. 133
 - 5. 30
17. * A 150 lb sign is suspended from two cables as shown in figure 5. What is the tension in lbs. in rope 1?
- 1. 108
 - 2. 125

- 3. 75
- 4. 305
- 5. 100

18. Two children are sitting at the ends of a 6 m seesaw. The children weigh 250 N and 300 N respectively. How far, in m, from the 250 N child, should the pivot be placed if the seesaw is to be balanced? Assume that the seesaw has no weight for this problem.

- 1. 3.3
- 2. 2.7
- 3. 3.0
- 4. 3.5
- 5. 4.2

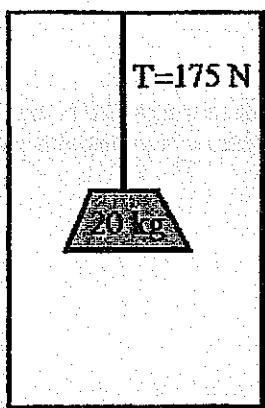
19. How much horizontal force (in Newtons) is needed to pull an 8.0 N pendulum ball aside until the pendulum cord makes an angle of 40° with respect to the vertical as shown in figure 6?

- 1. 6.7
- 2. 9.5
- 3. 5.1
- 4. 6.1
- 5. 2.9

20. In figure 7, a massless rod is suspended from one end at a pivot point. If $F_1 = 300$ N, then what must be the value of F_2 (in Newtons) so that the rod is in equilibrium?

- 1. 1200
 - 2. 600
 - 3. 693
 - 4. 346
 - 5. 946
-

Figure 1



$a=?$

Figure 2



Figure 3

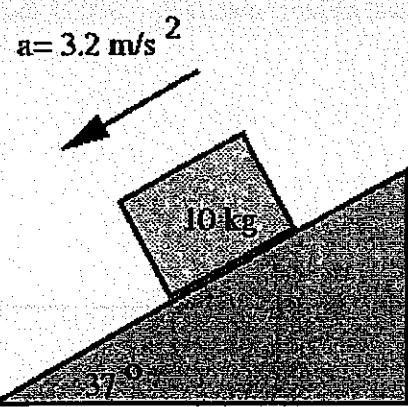


Figure 4

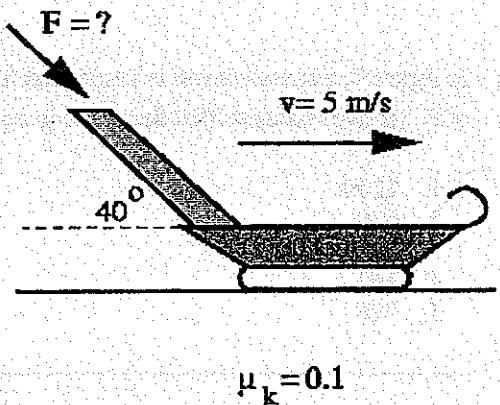


Figure 5

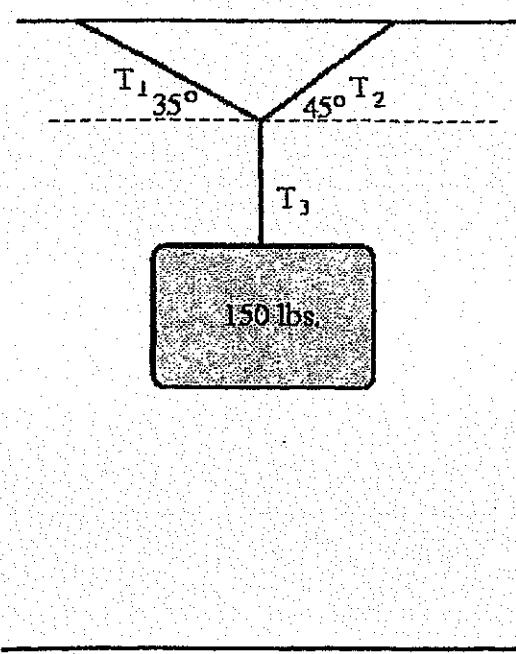


Figure 6

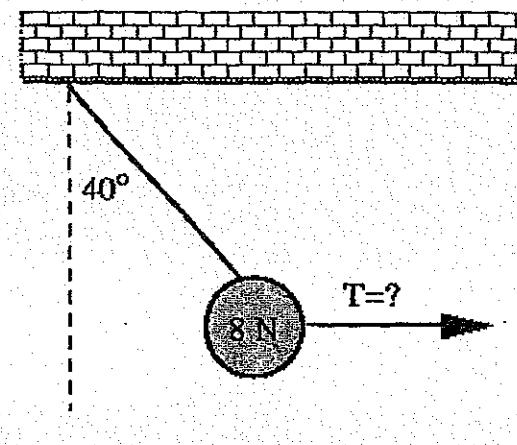
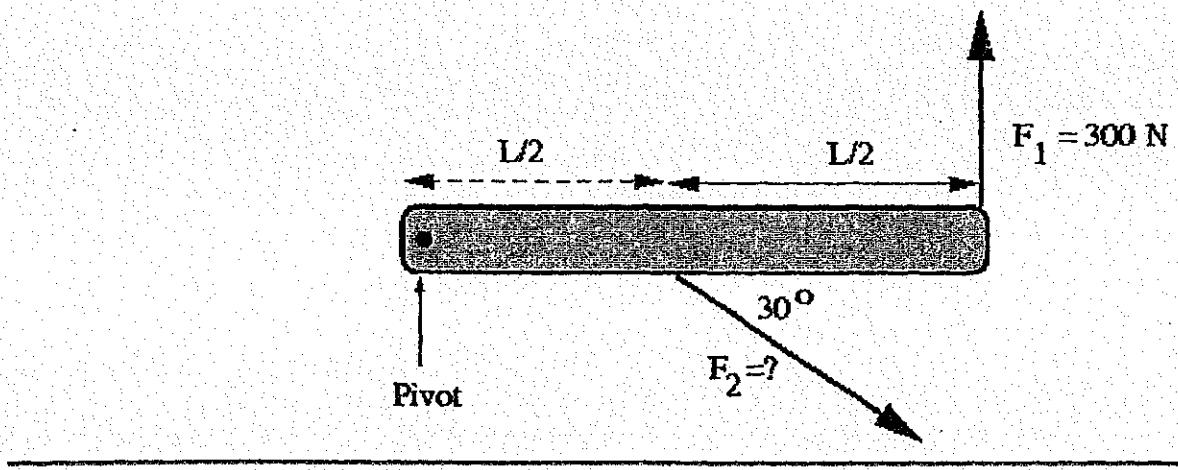
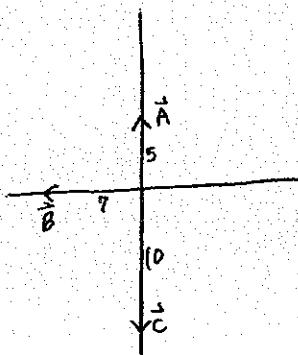


Figure 7



①



$$\vec{A} = \langle 0, 5 \rangle$$

$$\vec{B} = \langle -7, 0 \rangle$$

$$\vec{C} = \langle 0, -10 \rangle$$

$$\vec{A} + \vec{B} - 2\vec{C} = \langle 0, 5 \rangle + \langle -7, 0 \rangle - 2\langle 0, -10 \rangle$$

$$= \langle -7, 25 \rangle$$

$$|\langle -7, 25 \rangle| = \sqrt{(-7)^2 + (25)^2} \approx 26.0$$

②

$$\vec{A} = \langle 20, 0 \rangle$$

$$\vec{B} = \langle 0, 10 \rangle$$

$$\vec{A} - 2\vec{B} = \langle 20, 0 \rangle - 2\langle 0, 10 \rangle = \langle 20, -20 \rangle$$

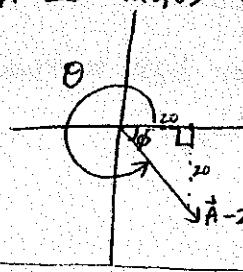
$$\phi = ?$$

$$\tan \phi = \frac{20}{20} = 1$$

$$\phi = \tan^{-1}(1) = 45^\circ$$

$$\phi = 45^\circ$$

$$\theta = 360^\circ - 45^\circ = 315^\circ$$



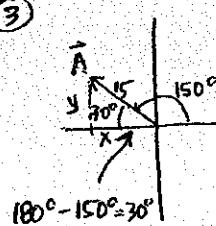
$$\cos(30^\circ) = \frac{x}{15}$$

$$x = (\cos 30)(15) \approx 13$$

By referring to the graph, you can see the x-component of A must be going in the -x-axis direction. thus x is negative.

$$x = -13$$

③



$$\cos(30^\circ) = \frac{x}{15}$$

$$x = (\cos 30)(15) \approx 13$$

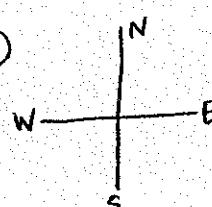
By referring to the graph, you can see the x-component of A must be going in the -x-axis direction. thus x is negative.

$$v_i = \langle 0, 10 \rangle$$

$$v_f = \langle -10, 0 \rangle$$

$$v_f - v_i = \langle -10, 0 \rangle - \langle 0, 10 \rangle = \langle -10, -10 \rangle$$

④



Let: N be +y-axis direction

E be +x-axis direction

S be -y-axis direction

W be -x-axis direction

$$v_f - v_i = \langle -10, 0 \rangle - \langle 0, 10 \rangle = \langle -10, -10 \rangle$$

Since Δv x-component is - , + y-component is - , Δv is in the SW direction.

⑤ $v_i = 15 \text{ ft/s}$ First, calculate time for melon to go up + then return to be level with roof:

$$t = 7.5 \text{ s}$$

$$v_i = 15 \text{ (so } v_f = -15)$$

$$y = ?$$

$$v_f = v_i + at$$

$$-15 = 15 + (-32.2)t$$

$$t_1 = .93 \text{ s}$$

Second, calculate time for melon to fall from height level w/ roof to pavement:

$$7.5 - t_1 = t_2 \Rightarrow 7.5 - .93 = 6.57 = t_2$$



NEXT PG

#5 cont...

$$y = v_0 t + \frac{1}{2} a t^2$$
$$= (-15)(6.57) + \frac{1}{2}(-32.2)(6.57)^2 \approx -793$$
$$|y| = 793 \text{ ft}$$

(6) $v_i = 75 \text{ km/hr}$ $\left| \begin{array}{c} 1 \text{ hr} \\ 3600 \text{ s} \end{array} \right| \left| \begin{array}{c} 1000 \text{ m} \\ 1 \text{ km} \end{array} \right| = \frac{75000 \text{ m}}{3600 \text{ s}} = 20.8 \text{ m/s}$

$$v_f = 0 \text{ m/s}$$

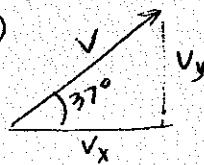
$$x = 200 \text{ m}$$

$$v_f^2 = v_i^2 + 2ad$$

$$0 = (20.8)^2 + 2a(200)$$

$$\rightarrow a \approx 1.1 \text{ m/s}^2$$

(7)



Time cannonball is in air is determined by v_y . Force of gravity only acts in y direction, so v_x is constant.

$$t = \frac{1200}{v_x}$$

Determine time, t_{y_2} , for ball to reach

$$v_y = 0: 0 = v_{iy} + (-9.8)t_{y_2}$$

$$v_f = v_i + at \Rightarrow \frac{v_{iy}}{-9.8} = t_{y_2}$$

$$\text{so } t = 2 \cdot t_{y_2} = \left(\frac{2 v_{iy}}{-9.8} \right)$$

$$\frac{1200}{v_x} = \frac{2 v_{iy}}{-9.8}$$

$$v_x v_{iy} = (1200)(-9.8)/2$$

set equal

$$\text{Note: } \tan(37) = \frac{v_{iy}}{v_x} \Rightarrow v_{iy} = v_x \tan 37$$

$$v_x(v_x \tan 37) = (1200)(-9.8)/2 \quad \text{substitute}$$

It's OK to drop the (-) sign in front of 9.8 m/s^2

$$\hookrightarrow v_x^2 = \frac{(1200)(9.8)}{2 \tan 37} = \cancel{1200} 7803$$

$$v_x = \sqrt{\cancel{1200} 7803} \approx \sqrt{7803} = 88.3$$

$$v_{iy} = v_x \tan 37 = 88.3 \tan 37 = 66.6$$

$$v = \sqrt{v_x^2 + v_{iy}^2} = \sqrt{(88.3)^2 + (66.6)^2} \approx 111 \text{ m/s}$$

(8) $v_i = \frac{60 \text{ mi}}{\text{hr}}$ $v_f = \frac{90 \text{ mi}}{\text{hr}}$ $t = 5 \text{ s}$ $\Rightarrow \frac{5 \text{ s}}{x} = \frac{3600 \text{ s}}{1 \text{ hr}} \Rightarrow 5 \text{ s} \approx .0014 \text{ hr}$

$$\frac{v_f - v_i}{t} = a \Rightarrow \frac{90 - 60}{.0014} \approx 21600 \text{ mi/hr}^2$$

$$\frac{21600 \text{ mi}}{\text{hr}^2} \cdot \left| \begin{array}{c} 5280 \text{ ft} \\ 1 \text{ mi} \end{array} \right| \left| \begin{array}{c} 1 \text{ hr} \\ 3600^2 \text{ s} \end{array} \right| = 8.8 \text{ ft/s}^2$$

$$(9) M_{\text{earth}} = 6 \times 10^{24} \text{ kg}$$

$$r_{\text{earth}} = 6.4 \times 10^3 \text{ km} = 6.4 \times 10^6 \text{ m}$$

$$G = 6.67 \times 10^{-11} \text{ Nm}^2/\text{kg}^2$$

$$F = m_0 g_x = \frac{G m_x m_0}{r_x^2}$$

where
○ stands for
some arbitrary object

$$g_x = \frac{G m_x}{r_x^2} = \frac{(6.67 \times 10^{-11})(6 \times 10^{24})}{(3 \cdot 6.4 \times 10^6)^2}$$

≈ 6.5

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$$(10) T = 174 \text{ N}$$

$$F = ma$$

$$174 = 20a$$

$$a = 8.7 \text{ m/s}^2$$

$$9 - 8.7 = 1.1$$

thus: 1.1 down

elevator must be going down for acceleration to be less than that of gravity

(11)

$$v_f^2 = v_i^2 + 2ad$$

$$v_i = 20 \text{ m/s} \quad v_f = 0$$

$$d = 100 \text{ m} \quad m = 2000$$

$$0 = 20^2 + (2a)(100)$$

$$a = -2$$

$$F = ma = (2000)(-2) = -4000 \text{ N}$$

$$|F| = 4000 \text{ N}$$

(12)



$$T_1 = ma = (1.6 + 1.6)a$$

$$5 = 3.2a \Rightarrow a = 1.56$$

$$T_2 = ma = (1.6)(1.56) = 2.5$$

$$(13) m = 55 \text{ kg}$$

$$t = 10 \text{ s}$$

$$v_f = v_i + at$$

$$0 = 5 + a(10)$$

$$a = -0.5 \text{ m/s}^2$$

$$F = ma = 55 \cdot -0.5 = -27.5 \Rightarrow |F| = 27.5$$

$$N = mg = 55 \cdot 9.8 = 539$$

$$27.5 = \mu 539$$

$$\mu = \frac{27.5}{539} \approx 0.05$$

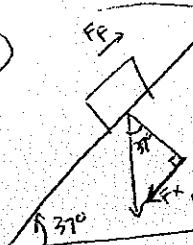
Forces acting on box are force of gravity, F_g , + force of friction, F_f

$$F = ma = F_g - F_f$$

$$(10)(3.2) = 59 - F_f$$

$$F_f \approx 27 \text{ N}$$

(14)



$$m = 10 \text{ kg}$$

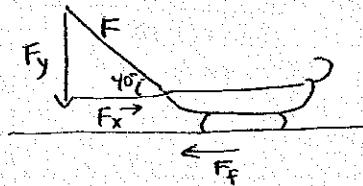
$$a = 3.2 \text{ m/s}^2$$

$$\sin(37) = \frac{F_x}{mg}$$

$$\sin(37)(mg) = F_x$$

$$\sin(37)(10)(9.8) = F_x = 59$$

(15)

For const speed, $F_x = F_f$.

$$F_f = \mu N = (0.1)(mg + F_y) = (0.1)((30)(9.8) + F_y)$$

$$F_f = (0.1)(30)(9.8) + (0.1)F_y = F_x$$

$$\tan 40 = \frac{F_y}{F_x} \Rightarrow F_y = F_x \tan 40$$

$$F_x = (0.1)(30)(9.8) + (0.1)F_x \tan 40$$

$$F_x - (0.1)\tan 40 F_x = (0.1)(30)(9.8)$$

$$F_x(1 - (0.1)\tan 40) = (0.1)(30)(9.8)$$

$$F_x = 32.1$$

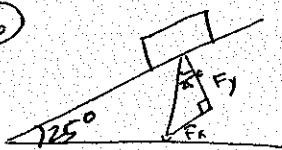
$$F_y = F_x \tan 40 = (32.1) \tan 40 = 26.9$$

$$F = \sqrt{F_x^2 + F_y^2}$$

$$= \sqrt{(32.1)^2 + (26.9)^2}$$

$$\approx 42 \text{ N}$$

(16)



$$\begin{aligned} \mu &= 0.6 \\ m &= 25 \text{ kg} \\ \theta &= 25^\circ \end{aligned}$$

$$f = \mu N$$

$$N \Rightarrow \cos 25 = \frac{N}{mg} \Rightarrow N = mg \cos 25 = (25)(9.8) \cos 25 = 222 \text{ N}$$

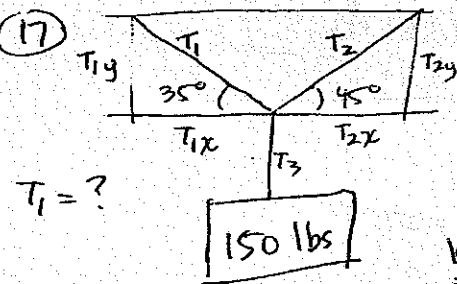
$$f = (0.6)(mg \cos 25) = (0.6)(222) = 133.2 \text{ N}$$

$$F_x \Rightarrow \sin 25 = \frac{F_x}{mg} \Rightarrow F_x = m g \sin 25 = (25)(9.8) \sin 25 = 103.5 \text{ N}$$

$$\begin{aligned} F_{\text{total}} &= 133.2 + 103.5 \approx 237 \text{ N} \\ F_{\text{total}} &= F + F_x \end{aligned}$$

(need to exert force equal to total force downwards for constant velocity)

(17)



$$T_1 = ?$$

$$150 \text{ lbs}$$

$$\sin 35 = \frac{T_{1y}}{T_1}$$

$$\cos 35 = \frac{T_{1x}}{T_1}$$

$$\sin 45 = \frac{T_{2y}}{T_2}$$

$$\cos 45 = \frac{T_{2x}}{T_2}$$

$$T_{1x} = T_{2x}$$

$$T(\cos 35) = T_2 (\cos 45)$$

$$T_2 = T_1 \left(\frac{\cos 35}{\cos 45} \right)$$

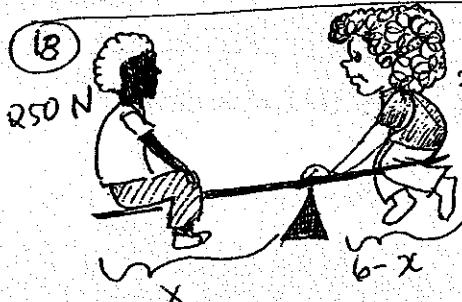
$$(\sin 35)T_1 + (\sin 45)T_2 = 150$$

Set up two eqns. w/ knowledge that all forces in X-direc. + Y-direc. must cancel out.

$$(\sin 35)T_1 + (\sin 45) \left(\frac{\cos 35}{\cos 45} \right) T_1 = 150$$

$$T_1 \approx 108$$

(18)



$$300 \text{ N}$$

$$x = Fd$$

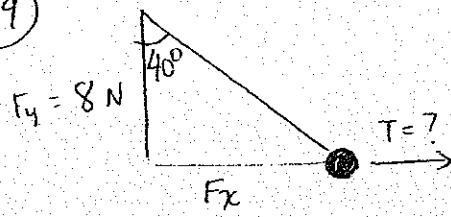
$$T_1 = T_2 \leftarrow \text{balanced seesaw}$$

$$(250)x = 300(6-x)$$

$$250x + 300x = 1800$$

$$x \approx 3.3 \text{ m}$$

(19)



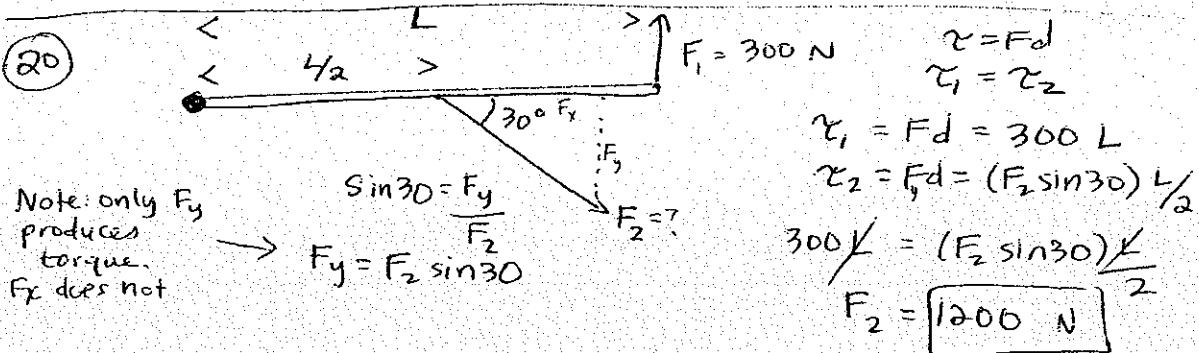
$$T = F_x$$

$$\tan 40^\circ = \frac{F_x}{8}$$

$$F_x = 8 \tan 40^\circ = 6.7 = T$$

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(20)



$$\sin 30^\circ = \frac{F_y}{F_2}$$

$$F_y = F_2 \sin 30^\circ$$

FINIS

$$\tau = F_d$$

$$\tau_1 = \tau_2$$

$$\tau_1 = F_d = 300 L$$

$$\tau_2 = F_d = (F_2 \sin 30^\circ) L/2$$

$$300 L = (F_2 \sin 30^\circ) L/2$$

$$F_2 = 1200 \text{ N}$$

PHY2004, Stanton

|||||||

NAME

(PRINT) -----

PHYSICS DEPARTMENT

Exam #2

October 24, 1996

(SIGNATURE) -----

PLEASE SIGN THE SHEET AT THE TOP. THIS INDICATES THAT YOU HAVE NOT DISCUSSED THIS TEST WITH ANYONE AND THAT YOU NEITHER HAVE GIVEN OR RECEIVED HELP FROM ANYONE OTHER THAN THE INSTRUCTOR/PROCTOR.

DIRECTIONS

- (1) Code your test number on your green answer sheet (use 76-80 for the 5-digit number). Code your name and student number on your answer sheet. Darken circles completely (errors can occur if too light).
- (2) Print your name on this sheet and sign it also.
- (3) For most questions, one of the answers listed will be considered correct. Sometimes none of the listed answers is close enough to be considered correct. In that case the correct answer will be no answer.
- (4) Do all scratch work on this exam to the right of the questions, and anywhere else on this exam. At the end of the test, this exam printout is to be turned in. No credit will be given without both the answer sheet and printout, with the scratch work which most questions demand of anyone.
- (5) Work the questions in any order. Incorrect answers are not taken into account in any way; you may guess at answers you don't know if you feel that a correct answer is listed. Guessing on all questions will most likely result in failure.
- (6) Black the circle of your intended answer completely, using a number 2 pencil on the answer sheet. Do not make any stray marks or the answer sheet may not read properly.
- (7) As an aid to the examiner (and yourself) in the case of poorly marked answer sheets, please circle your selected answer on the examination sheet.
- (8) Good luck!!!!

>>>>> BEFORE YOU FINISH <<<<<

Fold the computer print out so your name is on top, include any figure sheet inside the print out. Hand in the green answer sheet separately.

If none of the answers are correct, please leave the answer sheet blank. It is not our intention to omit the right answer, but in case of a mistake please leave the answer sheet blank.

$$g = 32.2 \text{ ft/s}^{**2} = 9.8 \text{ m/s}^{**2}$$

$$1 \text{ hp} = 746 \text{ watts}$$

* * Problems marked with a * (* *) are more (most) difficult. * *

1. An 80 kg skier, skies down a slope of 30 degrees (see figure 1). How much work is done (in Joules) BY GRAVITY when the skier is at a height 100 m below the original height?

1. 7.84×10^4
2. -7.84×10^4
3. 3.92×10^4
4. -3.92×10^4

5. 8.0×10^3

2. A fireman jumps down a 20 foot fire pole. Neglecting all friction (both with the pole and with the air) what is the speed, in miles per hour, of the fireman as he reaches the bottom of the slide?
1. 24.5
 2. 35.9
 3. 19.8
 4. 13.5
 5. 17.3
3. In figure 2 is shown a wire along which a 50-g bead slides. If friction forces can be ignored, and the bead starts from rest at A, how fast will it be going at point B in m/s?
1. 4.4
 2. 3.1
 3. 7.0
 4. 4.9
 5. 3.5
4. A crane is operated by a 100 hp motor. If it lifts its load at the rate of 0.1 m/s, then what is the maximum mass (in kg) that the crane can lift? Assume the crane is 100% efficient.
1. 7.6×10^4
 2. 7.5×10^5
 3. 102
 4. 1.0×10^5
 5. 746
5. A simple machine requires an input force of 80 N acting over a distance of 40 m to raise a 3500 N weight by 30 cm. What is the % efficiency of this machine?
1. 33
 2. 44
 3. 100
 4. 55
 5. 25
6. A pulley system consists of two sets of two pulleys as shown in figure 3. If the system has an efficiency of 85%, Then how much weight W, in lbs., can be lifted with a 150 lb input force?
1. 510

- 2. 600
 - 3. 638
 - 4. 255
 - 5. 383
7. What is the IMA of the lever system shown in figure 4?
- 1. 0.5
 - 2. 2
 - 3. 3
 - 4. 0.33
 - 5. 1.5
8. A certain hydraulic press has an output piston of 10.0 cm in diameter. The input piston has a diameter of 0.5 cm. How large a force (in N) must be supplied to the input piston to provide an output force of 30,000 N? Assume the press is ideal.
- 1. 75
 - 2. 1500
 - 3. 150
 - 4. 750
 - 5. 600
9. How large an impulse (in N-s) does a 20 g bullet moving at 400 m/s exert on a tree as it strikes and comes to rest in the tree?
- 1. 8
 - 2. 8000
 - 3. 20
 - 4. 20,000
 - 5. 1600
10. * A 2.5 kg ball is moving at 5.0 m/s in the +y direction. It strikes a stationary 6.0 kg ball and bounces off so that it is going 0.75 m/s in the +x direction. What is the x-component of the 6.0 kg ball after the collision (in m/s)?
- 1. -0.31
 - 2. 0.31
 - 3. 2.1
 - 4. -2.1
 - 5. 3.2
11. An 80 kg man on ice skates is moving at 6.5 m/s when he runs squarely into the back of a 60 kg

women on ice skates standing at rest. He holds onto her and they move off together. What is their speed (in m/s) after the collision?

- 1. 3.7
- 2. 2.8
- 3. 4.9
- 4. 8.7
- 5. 3.3

12. ** Particle A has mass 1 kg and is initially moving with a velocity of 2 m/s toward particle B which has mass 2 kg and is initially at rest. If they collide head on (i.e. in one dimension) and the collision is perfectly elastic, then what is the velocity (in m/s) of particle B after the collision?

- 1. 1.3
- 2. 1.0
- 3. -0.7
- 4. 2.7
- 5. 0.7

13. * What is the angular speed, in RADIANS/s of the Earth going around the Sun?

- 1. 2.0×10^{-7}
- 2. 3.2×10^{-8}
- 3. 7.2×10^{-4}
- 4. 7.3×10^{-5}
- 5. 4.8×10^{-6}

14. After the power is turned off to a motor whose shaft speed is 5000 revs/min, the motor takes 10.0 s to stop. Through how many REVOLUTIONS did the shaft turn while the motor came to a rest? Assume uniform acceleration.

- 1. 417
- 2. 833
- 3. 208
- 4. 25,000
- 5. 500

15. What is the maximum angular velocity (in RAD/s) that a 2 kg mass on a 1.5 m rope can be swung if the rope can support a tension of 350 N before breaking?

- 1. 10.8
- 2. 5.4
- 3. 67.9

4. 16.2
5. 117
16. If a bicycle is travelling at 40 km/h, how fast are its 70 cm diameter wheels turning in REV/S/MIN?
1. 303
 2. 5.1
 3. 152
 4. 48
 5. 952
17. A pendulum (shown in figure 5) has a WEIGHT of 98 N and length of 10 m. What is the moment of inertia of the pendulum about its fixed point in ($\text{kg}\cdot\text{m}^2$)? (Assume the rope has no mass.)
1. 1000
 2. 9800
 3. 980
 4. 100
 5. 4900
18. What is the moment of inertia for rotation in-plane about the center sphere for the masses shown in figure 6 in units of ($\text{kg}\cdot\text{m}^2$)? Take $m = 2.0 \text{ kg}$ and $r = 1.0 \text{ m}$. The black spheres have mass $2m$ and the white spheres have mass m .
1. 24
 2. 12
 3. 20
 4. 10
 5. 16
19. What is the rotational kinetic energy (in Joules) for a wheel that is rotating at 5.0 REV/S if I for the wheel is $2.7 \text{ kg}\cdot\text{m}^2$?
1. 1332
 2. 34
 3. 2665
 4. 68
 5. 46
20. A figure skater is spinning at the rate of 3 REV/S/sec. He pulls in his arms so that his new radius of gyration is 1/2 his original radius of gyration. What is his new angular velocity in REV/S/sec?

1. 12
2. 6
3. 0.5
4. 0.75
5. 1.5
-

Figure 1

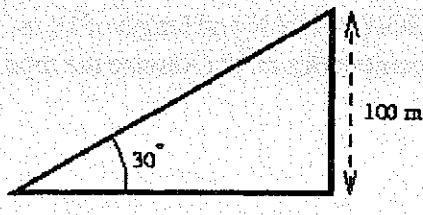


Figure 2

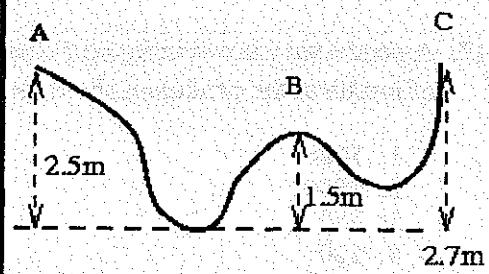


Figure 3

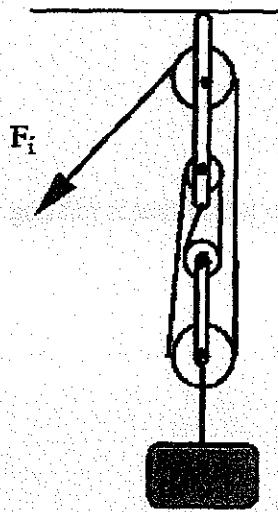


Figure 4

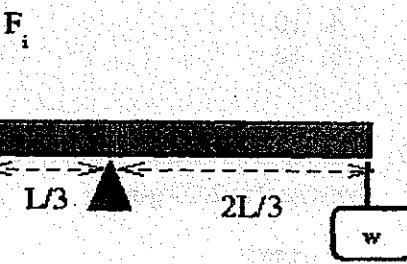


Figure 5

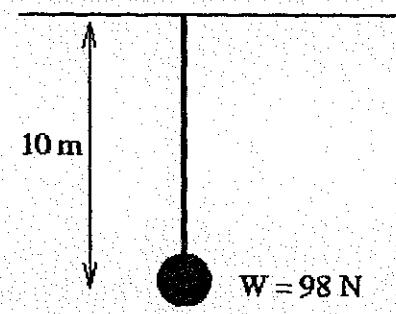
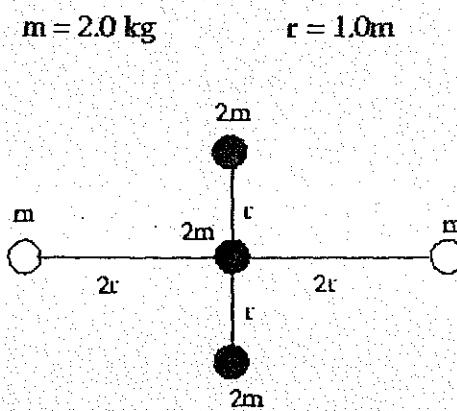


Figure 6



$$1. \quad W_{\text{gravity}} = mgh$$

$$= (80 \text{ kg})(9.8 \text{ m/s}^2)(100 \text{ m})$$

$$= 78400 \text{ J} = 7.84 \times 10^4 \text{ J}$$

2. Conservation of energy

$$PE_{\text{top}} = KE_{\text{bottom}}$$

$$mgh = \frac{1}{2}mv^2$$

$$v = \sqrt{2gh}$$

$$v = \sqrt{2(32.2 \text{ ft/l s}^2)(20 \text{ ft})} = \sqrt{1288} \frac{\text{ft}}{\text{sec}}$$

$$\cdot (\sqrt{1288} \frac{\text{ft}}{\text{sec}}) \times \left(\frac{1 \text{ mile}}{5280 \text{ ft}}\right) \times \left(\frac{3600 \text{ sec}}{1 \text{ hr}}\right) = 24.5 \text{ mi/hr}$$

$$3. \quad PE_n - PE_B = KE_B$$

$$mg(h_A - h_B) = \frac{1}{2}mv^2$$

$$v = \sqrt{2g(h_A - h_B)} = \sqrt{2(9.8 \text{ m/s}^2)(2.5 \text{ m} - 1.5 \text{ m})} = 4.4 \text{ m/s}$$

$$4. \quad 1 \text{ hp} = 746 \text{ watts}$$

$$100 \text{ hp} \times 746 \frac{\text{watts}}{\text{hp}} = 74,600 \text{ W}$$

$$P = F \cdot v$$

$$74600 \text{ W} = F(1 \text{ m/s})$$

$$F = 74600 \text{ N} = mg$$

$$M = \frac{74600 \text{ N}}{9.8 \text{ m/s}^2} = 7.6 \times 10^4 \text{ kg}$$

$$5. \quad \text{efficiency} = \frac{W_{\text{out}}}{W_{\text{in}}} \times 100 = \frac{(F \cdot d)_{\text{out}}}{(F \cdot d)_{\text{in}}} \times 100$$

$$= \frac{(3500 \text{ N})(.35 \text{ m})}{(80 \text{ N})(40 \text{ m})} \times 100$$

$$= 33\%$$

6. efficiency = $\frac{W_{out}}{W_{in}} \times 100 = \frac{(F \cdot d)_{out}}{(F \cdot d)_{in}} \times 100$

ratio of $\frac{d_{out}}{d_{in}} = \frac{1}{4}$ (4 pulleys distance for the input force)

$$\therefore 85\% = \left(\frac{F_{out}}{150\text{lb}} \right) \left(\frac{1}{4} \right) \times 100$$

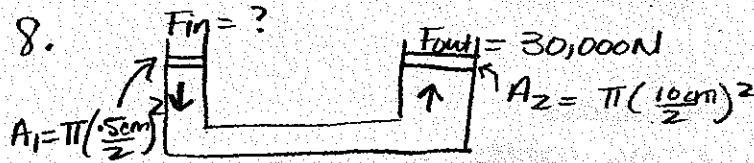
$$F_{out} = 510 \text{ lbs.}$$

7. conservation of Torque

$$W \left(\frac{2L}{3} \right) = F_i \left(\frac{L}{3} \right)$$

$$2W = F_i$$

$$IMA = \frac{W}{F_i} = \frac{W}{2W} = \frac{1}{2} = 0.5$$



$$\frac{F_{in}}{A_1} = \frac{F_{out}}{A_2}$$

$$F_{in} = 30,000\text{N} \left(\frac{A_1}{A_2} \right)$$

$$= 30,000\text{N} \left(\frac{0.025\text{cm}^2}{25\text{cm}^2} \right)$$

$$F_{in} = 75\text{N}$$

9.

Impulse = $F_{x,t} = \Delta m \cdot v$
 $= m \Delta v$
 $= (0.020\text{kg})(400\text{m/s})$
 $= 8\text{ N}\cdot\text{s}$

10. $P_{xi} = P_{xf}$

$$0 = (4.0\text{kg})v + (2.5\text{kg})(-75\text{m/s})$$

$$V = -0.31\text{ m/s}$$

$$11. P_i = P_f, m_1 = 80 \text{ kg}, v_1 = 6.5 \text{ m/s}, m_2 = 60 \text{ kg}$$

$$m_1 v_{1i} = (m_1 + m_2) v_f \quad (\text{inelastic collision})$$

$$v_f = \frac{m_1 v_{1i}}{(m_1 + m_2)} = \frac{80 \times 6.5}{140} = 3.7 \text{ m/s}$$

12. Conservation of momentum

$$P_i = P_f$$

$$(m_1 v_1)_i = (m_1 + v_1)_f + (m_2 v_2)_f$$

$$\textcircled{1} \quad 2 \text{ N.s} = v_{1f} + 2 v_{2f}$$

$$v_{1f} = 2 - 2 v_{2f}$$

Conservation of kinetic energy

$$KE_i = KE_f$$

$$\left(\frac{1}{2} m_1 v_1^2 \right)_i = \left(\frac{1}{2} m_1 v_1^2 + \frac{1}{2} m_2 v_2^2 \right)_f$$

replace v_{1f} with $\textcircled{1}$

$$\bullet 2 = \frac{1}{2} m_1 (2 - 2 v_{2f})^2 + \frac{1}{2} m_2 v_{2f}^2$$

$$2 = \frac{1}{2} m_1 (4 - 8 v_{2f} + 4 v_{2f}^2) + \frac{1}{2} m_2 v_{2f}^2$$

$$2 = 2 - 4 v_{2f} + 2 v_{2f}^2 + v_{2f}^2$$

$$\textcircled{2} = v_{2f} (3 v_{2f} - 4)$$

$$v_{2f} = \textcircled{4/3 m/s}, 0 \text{ m/s}$$

$$= 1.3 \text{ m/s}$$

$$13. 1 \text{ revolution} = 365 \text{ days}$$

$$\frac{1 \text{ rev}}{365 \text{ days}} \times \frac{1 \text{ day}}{24 \text{ hr}} \times \frac{1 \text{ hr}}{3600 \text{ s}} \times \frac{2\pi \text{ rad}}{1 \text{ rev}} = 0.7 \times 10^{-7} \frac{\text{rad}}{\text{sec}}$$

$$14. \quad v_f = v_i + at$$

$$0 = \left(\frac{5000 \text{ rev}}{60 \text{ sec}}\right) + a(10 \text{ sec})$$

$$a = -\frac{5000 \text{ rev}}{600 \text{ sec}^2}$$

$$d = v_i t + \frac{1}{2} a t^2$$

$$d = \left(\frac{5000 \text{ rev}}{60 \text{ sec}}\right)(10 \text{ sec}) - \frac{1}{2} \left(\frac{5000 \text{ rev}}{600 \text{ sec}^2}\right)(10 \text{ sec})^2$$

$$d = 417 \text{ rev}$$

$$15. \quad v = rw$$

$$F = \frac{mv^2}{r} = \frac{mrw^2 r^2}{r} = mrw^2$$

$$w = \sqrt{\frac{F}{mr}} = \sqrt{\frac{350}{2 \times 1.5}} = 10.8 \text{ rad/s}$$

$$16. \quad w = \frac{v}{r}$$

$$w = \frac{40 \text{ km}}{\text{hr}} \times \frac{1 \text{ hr}}{60 \text{ min}} \times \frac{1000 \text{ m}}{1 \text{ km}} \times \frac{1 \text{ rev}}{2\pi \text{ rad}} \times \left(\frac{1}{35 \text{ m}}\right) \text{ rev radius}$$

$$= 303 \frac{\text{rev}}{\text{min}}$$

$$17. \quad I = mr^2$$

$$= \left(\frac{98 \text{ N}}{9.8 \text{ m/s}^2}\right) (10 \text{ m})^2$$

$$= 1000 \text{ kgm}^2$$

$$18. \quad I = \sum mr^2 = (2 \text{ kg} \times (2 \text{ m})^2) + (2 \times 2 \text{ kg} \times (1 \text{ m})^2) + (2 \times 2 \text{ kg} \times 1 \text{ m}^2) + (2 \text{ kg} \times 0 \text{ m}^2)$$

$$= 24$$

* distance from the origin

$$19. \quad \text{Rotational KE} = \frac{1}{2} (\sum mr^2) w^2$$

$$I = \sum mr^2 = 2.7 \text{ kgm}^2$$

$$\text{KE} = \frac{1}{2} (2.7 \text{ kgm}^2) \left(5.0 \text{ rev/s} \times 2\pi \frac{\text{rad}}{\text{rev}}\right)^2$$

$$= 1332 \text{ J}$$

$$20. \quad L_i = L_f$$

$$I_i w_i = I_f w_f$$

$$\left(\frac{1}{2}mr^2\right)_i w_i = \left(\frac{1}{2}mr^2\right)_f w_f$$

$$w_i = \frac{1}{4} w_f$$

$$w_f = 4 w_i$$

$$w_f = 12 \text{ revs/sec}$$

