 77777

Instructor(s): *Field/Matcheva/Detweiler*

PHYSICS DEPARTMENT

PHY 2048 Final Exam April 25, 2015

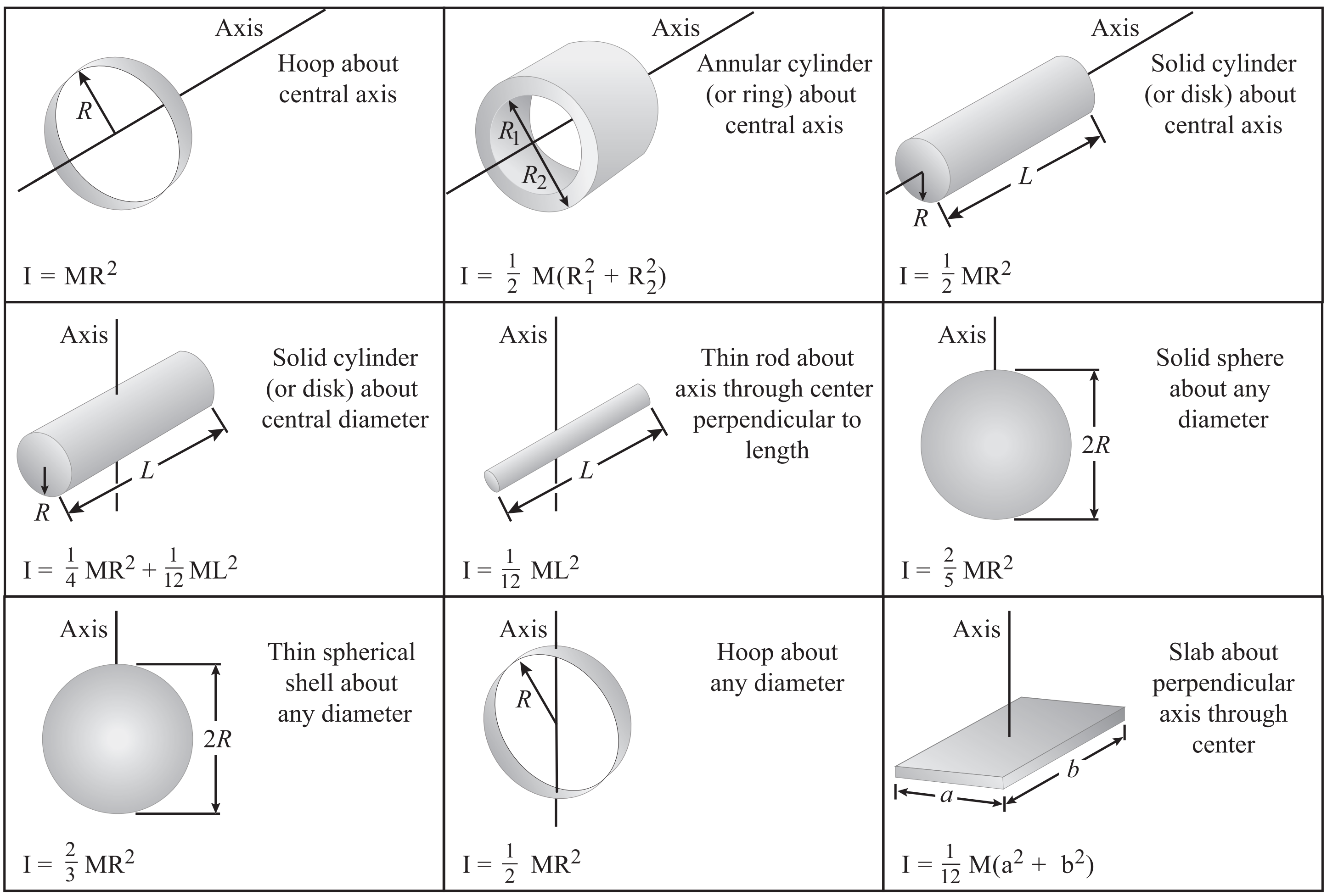
Name (print, last first): ______________________ Signature: ______________________

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 lines 76–80 on the answer sheet for the 5-digit number)**. Code your name on your answer sheet. **DARKEN CIRCLES COMPLETELY**. Code your UFID 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. **Circle your answers on the test form.** 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.
(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 some answers may be counted as incorrect.
(5) **The answers are rounded off. Choose the closest to exact. There is no penalty for guessing. If you believe that no listed answer is correct, leave the form blank.**
(6) Hand in the answer sheet separately.

Use $g = 9.80$ m/s^2



PHY2048 Exam 1 Formula Sheet

Vectors

$\vec{a} = a_x\hat{i} + a_y\hat{j} + a_z\hat{k}$ $\vec{b} = b_x\hat{i} + b_y\hat{j} + b_z\hat{k}$ Magnitudes: $|\vec{a}| = \sqrt{a_x^2 + a_y^2 + a_z^2}$ $|\vec{b}| = \sqrt{b_x^2 + b_y^2 + b_z^2}$

Scalar Product: $\vec{a} \cdot \vec{b} = a_x b_x + a_y b_y + a_z b_z$ Magnitude: $\vec{a} \cdot \vec{b} = |\vec{a}||\vec{b}|\cos\theta$ (θ = angle between $\vec{a}$ and $\vec{b}$)

Vector Product: $\vec{a} \times \vec{b} = (a_y b_z - a_z b_y)\hat{i} + (a_z b_x - a_x b_z)\hat{j} + (a_x b_y - a_y b_x)\hat{k}$

Magnitude: $|\vec{a} \times \vec{b}| = |\vec{a}||\vec{b}|\sin\theta$ (θ = smallest angle between $\vec{a}$ and $\vec{b}$)

Motion

Displacement: $\Delta x = x(t_2) - x(t_1)$ (1 dimension) $\Delta\vec{r} = \vec{r}(t_2) - \vec{r}(t_1)$ (3 dimensions)

Average Velocity: $v_{ave} = \dfrac{\Delta x}{\Delta t} = \dfrac{x(t_2) - x(t_1)}{t_2 - t_1}$ (1 dim) $\vec{v}_{ave} = \dfrac{\Delta\vec{r}}{\Delta t} = \dfrac{\vec{r}(t_2) - \vec{r}(t_1)}{t_2 - t_1}$ (3 dim)

Average Speed: s_{ave} = (total distance)/Δt

Instantaneous Velocity: $v(t) = \dfrac{dx(t)}{dt}$ (1 dim) $\vec{v}(t) = \dfrac{d\vec{r}(t)}{dt}$ (3 dim)

Relative Velocity: $\vec{v}_{AC} = \vec{v}_{AB} + \vec{v}_{BC}$ (3 dim)

Average Acceleration: $a_{ave} = \dfrac{\Delta v}{\Delta t} = \dfrac{v(t_2) - v(t_1)}{t_2 - t_1}$ (1 dim) $\vec{a}_{ave} = \dfrac{\Delta\vec{v}}{\Delta t} = \dfrac{\vec{v}(t_2) - \vec{v}(t_1)}{t_2 - t_1}$ (3 dim)

Instantaneous Acceleration: $a(t) = \dfrac{dv(t)}{dt} = \dfrac{d^2x(t)}{dt^2}$ (1 dim) $\vec{a}(t) = \dfrac{d\vec{v}(t)}{dt} = \dfrac{d^2\vec{r}(t)}{dt^2}$ (3 dim)

Equations of Motion (Constant Acceleration)

$v_x(t) = v_{x0} + a_x t$ $v_y(t) = v_{y0} + a_y t$ $v_z(t) = v_{z0} + a_z t$

$x(t) = x_0 + v_{x0}t + \frac{1}{2}a_x t^2$ $y(t) = y_0 + v_{y0}t + \frac{1}{2}a_y t^2$ $z(t) = z_0 + v_{z0}t + \frac{1}{2}a_z t^2$

$v_x^2(t) = v_{x0}^2 + 2a_x(x(t) - x_0)$ $v_y^2(t) = v_{y0}^2 + 2a_y(y(t) - y_0)$ $v_z^2(t) = v_{z0}^2 + 2a_z(z(t) - z_0)$

Newton's Law and Weight

$\vec{F}_{net} = m\vec{a}$ (m = mass) Weight (near the surface of the Earth) = W = mg (use g = 9.8 m/s^2)

Magnitude of the Frictional Force

(μ_s = static coefficient of friction, μ_k = kinetic coefficient of friction)

Static: $(f_s)_{\max} = \mu_s F_N$ Kinetic: $f_k = \mu_k F_N$ (F_N is the magnitude of the normal force)

Uniform Circular Motion (Radius R, Tangential Speed v = Rω, Angular Velocity ω)

Centripetal Acceleration & Force: $a = \dfrac{v^2}{R} = R\omega^2$ $F = \dfrac{mv^2}{R} = mR\omega^2$ Period: $T = \dfrac{2\pi R}{v} = \dfrac{2\pi}{\omega}$

Projectile Motion

(horizontal surface near Earth, v_0 = initial speed, θ_0 = initial angle with horizontal)

Range: $R = \dfrac{v_0^2\sin(2\theta_0)}{g}$ Max Height: $H = \dfrac{v_0^2\sin^2\theta_0}{2g}$ Time (of flight): $t_f = \dfrac{2v_0\sin\theta_0}{g}$

Quadratic Formula

If: $ax^2 + bx + c = 0$ Then: $x = \dfrac{-b \pm \sqrt{b^2 - 4ac}}{2a}$

PHY2048 Exam 2 Formula Sheet

Work (W), Mechanical Energy (E), Kinetic Energy (KE), Potential Energy (U)

Kinetic Energy: $KE = \frac{1}{2}mv^2$ Work: $W = \int_{\vec{r}_1}^{\vec{r}_2} \vec{F} \cdot d\vec{r} \xrightarrow[\text{Constant } \vec{F}]{} \vec{F} \cdot \vec{d}$ Power: $P = \frac{dW}{dt} = \vec{F} \cdot \vec{v}$

Work-Energy Theorem: $KE_f = KE_i + W$ Potential Energy: $\Delta U = -\int_{\vec{r}_1}^{\vec{r}_2} \vec{F} \cdot d\vec{r}$ $F_x(x) = -\frac{dU(x)}{dx}$

Work-Energy: W(external) = ΔKE + ΔU + ΔE(thermal) + ΔE(internal) Work: W = -ΔU

Gravity Near the Surface of the Earth (y-axis up): $F_y = -mg$ $U(y) = mgy$

Spring Force: $F_x(x) = -kx$ $U(x) = \frac{1}{2}kx^2$

Mechanical Energy: $E = KE + U$ Isolated and Conservative System: $\Delta E = \Delta KE + \Delta U = 0$ $E_f = E_i$

Linear Momentum, Angular Momentum, Torque

Linear Momentum: $\vec{p} = m\vec{v}$ $\vec{F} = \frac{d\vec{p}}{dt}$ Kinetic Energy: $KE = \frac{p^2}{2m}$ Impulse: $\vec{J} = \Delta\vec{p} = \int_{t_i}^{t_f} \vec{F}(t)dt$

Center of Mass (COM): $M_{tot} = \sum_{i=1}^{N} m_i$ $\vec{r}_{COM} = \frac{1}{M_{tot}}\sum_{i=1}^{N} m_i\vec{r}_i$ $\vec{v}_{COM} = \frac{1}{M_{tot}}\sum_{i=1}^{N} \vec{p}_i$

Net Force: $\vec{F}_{net} = \frac{d\vec{P}_{tot}}{dt} = M_{tot}\vec{a}_{COM}$ $\vec{P}_{tot} = M_{tot}\vec{v}_{COM} = \sum_{i=1}^{N} \vec{p}_i$

Moment of Inertia: $I = \sum_{i=1}^{N} m_i r_i^2$ (discrete) $I = \int r^2 dm$ (uniform) Parallel Axis: $I = I_{COM} + Mh^2$

Angular Momentum: $\vec{L} = \vec{r} \times \vec{p}$ Torque: $\vec{\tau} = \vec{r} \times \vec{F} = \frac{d\vec{L}}{dt}$ Work: $W = \int_{\theta_i}^{\theta_f} \tau d\theta$

Conservation of Linear Momentum: if $\vec{F}_{net} = \frac{d\vec{p}}{dt} = 0$ then $\vec{p}$ = constant and $\vec{p}_f = \vec{p}_i$

Conservation of Angular Momentum: if $\vec{\tau}_{net} = \frac{d\vec{L}}{dt} = 0$ then $\vec{L}$ = constant and $\vec{L}_f = \vec{L}_i$

Rotational Varables

Angular Position: $\theta(t)$ Angular Velocity: $\omega(t) = \frac{d\theta(t)}{dt}$ Angular Acceleration: $\alpha(t) = \frac{d\omega(t)}{dt} = \frac{d^2\theta(t)}{dt^2}$

Torque: $\tau_{net} = I\alpha$ Angular Momentum: $L = I\omega$ Kinetic Energy: $E_{rot} = \frac{1}{2}I\omega^2 = \frac{L^2}{2I}$ Power: $P = \tau\omega$

Arc Length: $s = R\theta$ Tangential Speed: $v = R\omega$ Tangential Acceleration: $a = R\alpha$

Rolling Without Slipping: $x_{COM} = R\theta$ $v_{COM} = R\omega$ $a_{COM} = R\alpha$ $KE = \frac{1}{2}Mv_{COM}^2 + \frac{1}{2}I_{COM}\omega^2$

Rotational Equations of Motion (Constant Angular Acceleration α)

$$\omega(t) = \omega_0 + \alpha t$$

$$\theta(t) = \theta_0 + \omega_0 t + \tfrac{1}{2}\alpha t^2$$

$$\omega^2(t) = \omega_0^2 + 2\alpha(\theta(t) - \theta_0)$$

PHY2048 Exam 3 Formula Sheet

Law of Gravitation

Magnitude of Force: $F_{grav} = G\frac{m_1 m_2}{r^2}$ $G = 6.67\times10^{-11} Nm^2/kg^2$

Potential Energy: $U_{grav} = -G\frac{m_1 m_2}{r}$ Escape Speed: $v_{escape} = \sqrt{\frac{2GM}{R}}$

Tension & Compression (Y = Young's Modulus, B = Bulk Modulus)

Linear: $\frac{F}{A} = Y\frac{\Delta L}{L}$ Volume: $P = \frac{F}{A} = B\frac{\Delta V}{V}$

Ideal Fluids

Pressure (variable force): $P = \frac{dF}{dA}$ Pressure (constant force): $P = \frac{F}{A}$ Units: 1 Pa = 1 N/m^2

Equation of Continuity: $R_V = Av =$ constant (volume flow rate) $R_m = \rho Av =$ constant (mass flow rate)

Bernoulli's Equation (y-axis up): $P_1 + \frac{1}{2}\rho v_1^2 + \rho g y_1 = P_2 + \frac{1}{2}\rho v_2^2 + \rho g y_2 =$ constant

Fluids at rest (y-axis up): $P_2 = P_1 + \rho g(y_1 - y_2)$ Buoyancy Force: $F_{Buoy} = M_{fluid}\, g$

Simple Harmonic Motion (SHM) (angular frequency ω = 2πf =2π/T)

$x(t) = x_{\max}\cos(\omega t + \phi)$ $v_{\max} = \omega x_{\max}$

$v(t) = -\omega x_{\max}\sin(\omega t + \phi)$ $a_{\max} = \omega^2 x_{\max}$

$a(t) = -\omega^2 x_{\max}\cos(\omega t + \phi) = -\omega^2 x(t)$

Ideal Spring (k = spring constant)): $F_x = -kx$ $\omega = \sqrt{\frac{k}{m}}$ $E = \frac{1}{2}mv^2(t) + \frac{1}{2}kx^2(t) =$ constant

Sinusoidal Traveling Waves (frequency f = 1/T = ω/2π, wave number k = 2π/λ)

$y(x,t) = y_{\max}\sin(\Phi) = y_{\max}\sin(kx \pm \omega t + \phi)$ (- = right moving, + = left moving)

Phase: $\Phi = kx \pm \omega t$ Wave Speed: $v_{wave} = \frac{\omega}{k} = \frac{\lambda}{T} = \lambda f$ Wave Speed (tight string): $v_{wave} = \sqrt{\frac{\tau}{\mu}}$

Interference (Max Constructive): $\Delta\Phi = 2\pi n$ $n = 0,\pm1,\pm2,\cdots$ $\Delta d = n\lambda$ $n = 0,\pm1,\pm2,\cdots$

Interference (Max Destructive): $\Delta\Phi = \pi + 2\pi n$ $n = 0,\pm1,\pm2,\cdots$ $\Delta d = (n + \frac{1}{2})\lambda$ $n = 0,\pm1,\pm2,\cdots$

Standing Waves (L = length, n = harmonic number)

Allowed Wavelengths & Frequencies: $\lambda_n = 2L/n$ $f_n = \frac{v_{wave}}{\lambda_n} = \frac{n v_{wave}}{2L}$ $n = 1,2,3\cdots$

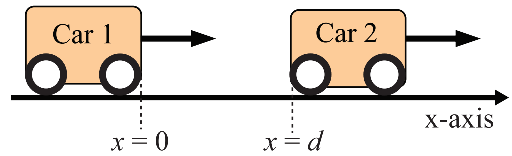
Sound Waves (P = Power)

Intensity (W/m^2): $I = \frac{P}{A}$ Isotropic Point Source: $I(r) = \frac{P_{source}}{4\pi r^2}$ Speed of Sound: $v_{sound} = \sqrt{\frac{B}{\rho}}$

Doppler Shift: $f_{obs} = f_S\frac{v_{sound} - v_D}{v_{sound} - v_S}$ (f_S = frequency of source, v_S, v_D = speed of source, detector)

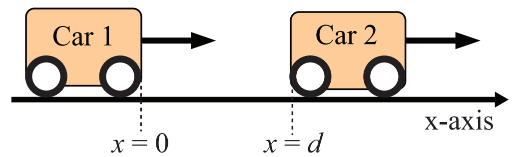
Change $-v_D$ to $+v_D$ if the detector is moving opposite the direction of the propagation of the sound wave.
Change $-v_S$ to $+v_S$ if the source is moving opposite the direction of the propagation of the sound wave.

1. Two automobiles start from rest on the x-axis as shown in the figure. Car 1 is at $x = 0$ and car 2 is at $x = d$. At $t = 0$ the two cars begin to move in the positive x direction at constant accelerations. If the magnitude of the acceleration of car 1 is twice the magnitude of the acceleration of car 2, at what point along the x-axis will the two cars meet?



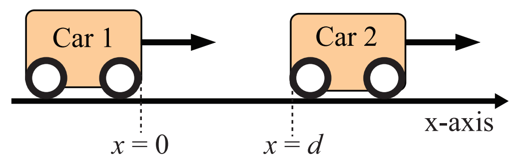
(1) $x = 2d$ (2) $x = 3d/2$ (3) $x = 4d/3$ (4) $x = 3d$ (5) $x = 4d$

2. Two automobiles start from rest on the x-axis as shown in the figure. Car 1 is at $x = 0$ and car 2 is at $x = d$. At $t = 0$ the two cars begin to move in the positive x direction at constant accelerations. If the magnitude of the acceleration of car 1 is three times the magnitude of the acceleration of car 2, at what point along the x-axis will the two cars meet?



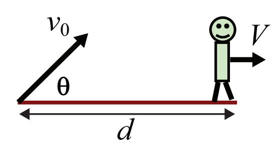
(1) $x = 3d/2$ (2) $x = 2d$ (3) $x = 4d/3$ (4) $x = 3d$ (5) $x = 4d$

3. Two automobiles start from rest on the x-axis as shown in the figure. Car 1 is at $x = 0$ and car 2 is at $x = d$. At $t = 0$ the two cars begin to move in the positive x direction at constant accelerations. If the magnitude of the acceleration of car 1 is four times the magnitude of the acceleration of car 2, at what point along the x-axis will the two cars meet?



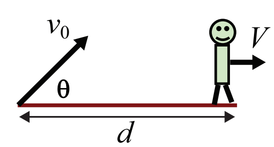
(1) $x = 4d/3$ (2) $x = 2d$ (3) $x = 3d/2$ (4) $x = 3d$ (5) $x = 4d$

4. On a flat horizontal soccer field near the surface of the Earth the goal keeper kicks the ball with initial speed $v_0 = 20$ m/s at an angle $\theta = 45°$ with the horizontal towards a teammate that is at rest a distance $d = 10$ m away as shown in the figure. At the instant the ball is kicked, the teammate begins running at a constant speed V away from the goal keeper. What constant speed V (in m/s) must the teammate run in order to reach the ball at the instant it hits the ground?



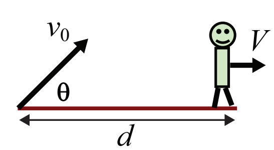
(1) 10.7 (2) 7.2 (3) 3.7 (4) 4.8 (5) 15.2

5. On a flat horizontal soccer field near the surface of the Earth the goal keeper kicks the ball with initial speed $v_0 = 20$ m/s at an angle $\theta = 45°$ with the horizontal towards a teammate that is at rest a distance $d = 20$ m away as shown in the figure. At the instant the ball is kicked, the teammate begins running at a constant speed V away from the goal keeper. What constant speed V (in m/s) must the teammate run in order to reach the ball at the instant it hits the ground?



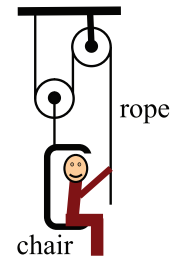
(1) 7.2 (2) 10.7 (3) 3.7 (4) 4.8 (5) 15.2

6. On a flat horizontal soccer field near the surface of the Earth the goal keeper kicks the ball with initial speed $v_0 = 20$ m/s at an angle $\theta = 45°$ with the horizontal towards a teammate that is at rest a distance $d = 30$ m away as shown in the figure. At the instant the ball is kicked, the teammate begins running at a constant speed V away from the goal keeper. What constant speed V (in m/s) must the teammate run in order to reach the ball at the instant it hits the ground?



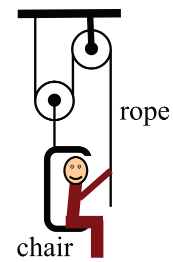
(1) 3.7 (2) 7.2 (3) 10.7 (4) 4.8 (5) 15.2

7. Near the surface of the Earth a man is sitting in a chair that is connected to the pulley system shown in the figure. The pulleys are frictionless and rope is massless. If the combined mass of the man and the chair is 90 kg, with what force (in N) must the man pull on the rope if he is to rise at a constant velocity?



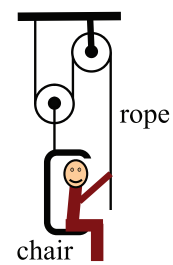
(1) 294
(2) 392
(3) 490
(4) 882
(5) 441

8. Near the surface of the Earth a man is sitting in a chair that is connected to the pulley system shown in the figure. The pulleys are frictionless and rope is massless. If the combined mass of the man and the chair is 120 kg, with what force (in N) must the man pull on the rope if he is to rise at a constant velocity?



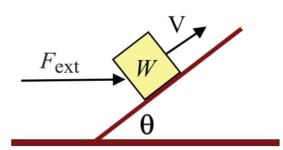
(1) 392
(2) 294
(3) 490
(4) 588
(5) 1176

9. Near the surface of the Earth a man is sitting in a chair that is connected to the pulley system shown in the figure. The pulleys are frictionless and rope is massless. If the combined mass of the man and the chair is 150 kg, with what force (in N) must the man pull on the rope if he is to rise at a constant velocity?



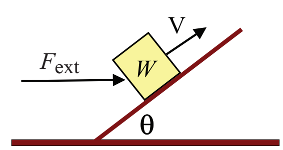
(1) 490
(2) 294
(3) 392
(4) 735
(5) 1470

10. A block with weight $W = 735$ N is being pushed up a frictionless ramp with angle $\theta = 30°$ relative to the horizontal at a constant speed by a horizontal force as shown in the figure. What is the magnitude of the force (in N) that the ramp exerts on the block?



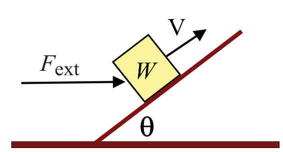
(1) 848.7 (2) 1039.4 (3) 1470.0 (4) 565.8 (5) 980.0

11. A block with weight $W = 735$ N is being pushed up a frictionless ramp with angle $\theta = 45°$ relative to the horizontal at a constant speed by a horizontal force as shown in the figure. What is the magnitude of the force (in N) that the ramp exerts on the block?



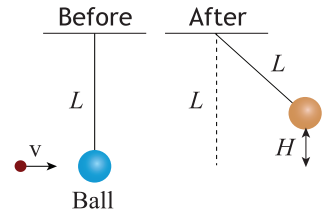
(1) 1039.4 (2) 848.7 (3) 1470.0 (4) 565.8 (5) 980.0

12. A block with weight $W = 735$ N is being pushed up a frictionless ramp with angle $\theta = 60°$ relative to the horizontal at a constant speed by a horizontal force as shown in the figure. What is the magnitude of the force (in N) that the ramp exerts on the block?



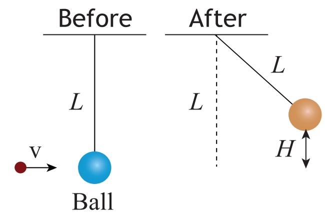
(1) 1470.0 (2) 848.7 (3) 1039.4 (4) 565.8 (5) 980.0

13. Near the surface of the Earth, a ball of mass M hangs vertically on a string of length L as shown in the figure. A lump of mud with mass m and horizontal speed v collides with the ball. The mud sticks to the ball causing it to swing on its string. If $m = M$, and the maximum vertical height the mud-ball system reaches after the collision is H, what is the initial speed v of the lump of mud?



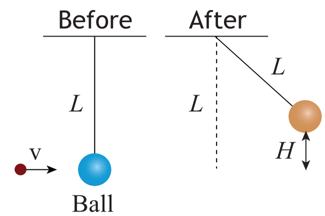
(1) $\sqrt{8gH}$ (2) $\sqrt{18gH}$ (3) $\sqrt{32gH}$ (4) $\sqrt{2gH}$ (5) $\sqrt{gH}$

14. Near the surface of the Earth, a ball of mass M hangs vertically on a string of length L as shown in the figure. A lump of mud with mass m and horizontal speed v collides with the ball. The mud sticks to the ball causing it to swing on its string. If $m = M/2$, and the maximum vertical height the mud-ball system reaches after the collision is H, what is the initial speed v of the lump of mud?



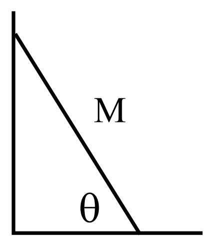
(1) $\sqrt{18gH}$ (2) $\sqrt{8gH}$ (3) $\sqrt{32gH}$ (4) $\sqrt{2gH}$ (5) $\sqrt{gH}$

15. Near the surface of the Earth, a ball of mass M hangs vertically on a string of length L as shown in the figure. A lump of mud with mass m and horizontal speed v collides with the ball. The mud sticks to the ball causing it to swing on its string. If $m = M/3$, and the maximum vertical height the mud-ball system reaches after the collision is H, what is the initial speed v of the lump of mud?



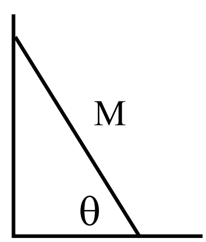
(1) $\sqrt{32gH}$ (2) $\sqrt{8gH}$ (3) $\sqrt{18gH}$ (4) $\sqrt{2gH}$ (5) $\sqrt{gH}$

16. A uniform ladder has length L and mass M. A window washer attempts to lean the ladder against a frictionless vertical wall as shown in the figure. He finds that the ladder slips on the ground when it is placed at an angle, θ, less than 30° to the ground, but remains in place when the angle is greater than 30°. What is the coefficient of static friction between the ladder and the ground?



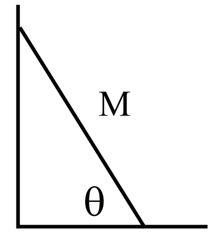
(1) 0.866 (2) 0.596 (3) 0.420 (4) 0.925 (5) 0.336

17. A uniform ladder has length L and mass M. A window washer attempts to lean the ladder against a frictionless vertical wall as shown in the figure. He finds that the ladder slips on the ground when it is placed at an angle, θ, less than 40° to the ground, but remains in place when the angle is greater than 40°. What is the coefficient of static friction between the ladder and the ground?



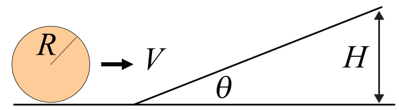
(1) 0.596 (2) 0.866 (3) 0.420 (4) 0.925 (5) 0.336

18. A uniform ladder has length L and mass M. A window washer attempts to lean the ladder against a frictionless vertical wall as shown in the figure. He finds that the ladder slips on the ground when it is placed at an angle, θ, less than $50°$ to the ground, but remains in place when the angle is greater than $50°$. What is the coefficient of static friction between the ladder and the ground?



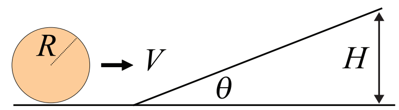
(1) 0.420 (2) 0.866 (3) 0.596 (4) 0.925 (5) 0.336

19. Near the surface of the Earth a solid object of mass M, radius R, and moment of inertia $I = MR^2/2$ rolls smoothly along a horizontal surface with speed V and up a ramp that makes an angle of θ with the horizontal surface as shown in the figure. What maximum height H does the object reach before rolling back down the incline?



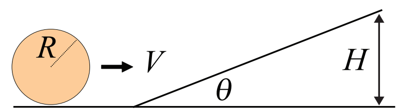
(1) $3V^2/(4g)$ (2) $2V^2/(3g)$ (3) $5V^2/(6g)$ (4) V^2/g (5) $V^2/(2g)$

20. Near the surface of the Earth a solid object of mass M, radius R, and moment of inertia $I = MR^2/3$ rolls smoothly along a horizontal surface with speed V and up a ramp that makes an angle of θ with the horizontal surface as shown in the figure. What maximum height H does the object reach before rolling back down the incline?



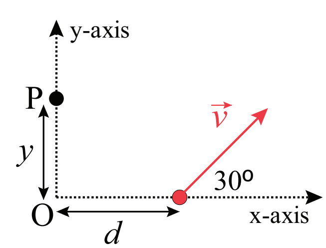
(1) $2V^2/(3g)$ (2) $3V^2/(4g)$ (3) $5V^2/(6g)$ (4) V^2/g (5) $V^2/(2g)$

21. Near the surface of the Earth a solid object of mass M, radius R, and moment of inertia $I = 2MR^2/3$ rolls smoothly along a horizontal surface with speed V and up a ramp that makes an angle of θ with the horizontal surface as shown in the figure. What maximum height H does the object reach before rolling back down the incline?



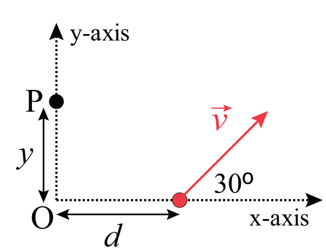
(1) $5V^2/(6g)$ (2) $3V^2/(4g)$ (3) $2V^2/(3g)$ (4) V^2/g (5) $V^2/(2g)$

22. A point particle with mass M and speed V is moving in the xy plane as shown in the figure. At the moment it crosses the x-axis ($y = 0$) at $x = d$, its velocity vector points at an angle of $30°$ relative to the x-axis and the magnitude of its angular momentum about the origin, ($i.e.$, $x = y = 0$) is L_0. What is the magnitude of its angular momentum about point P located on the y-axis a distanced $y = d/\sqrt{3}$ from the origin at this same moment?



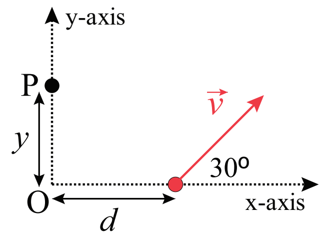
(1) $2L_0$ (2) $3L_0$ (3) $4L_0$ (4) $5L_0$ (5) $L_0/2$

23. A point particle with mass M and speed V is moving in the xy plane as shown in the figure. At the moment it crosses the x-axis ($y = 0$) at $x = d$, its velocity vector points at an angle of $30°$ relative to the x-axis and the magnitude of its angular momentum about the origin, ($i.e.$, $x = y = 0$) is L_0. What is the magnitude of its angular momentum about point P located on the y-axis a distanced $y = 2d/\sqrt{3}$ from the origin at this same moment?



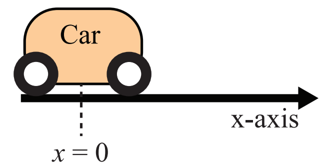
(1) $3L_0$ (2) $2L_0$ (3) $4L_0$ (4) $5L_0$ (5) $L_0/2$

24. A point particle with mass M and speed V is moving in the xy plane as shown in the figure. At the moment it crosses the x-axis ($y = 0$) at $x = d$, its velocity vector points at an angle of 30° relative to the x-axis and the magnitude of its angular momentum about the origin, (*i.e.*, $x = y = 0$) is L_0. What is the magnitude of its angular momentum about point P located on the y-axis a distanced $y = \sqrt{3}d$ from the origin at this same moment?



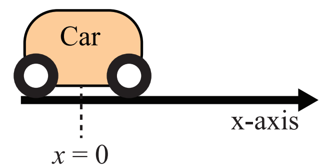
(1) $4L_0$ (2) $2L_0$ (3) $3L_0$ (4) $5L_0$ (5) $L_0/2$

25. An automobile starts from rest on the x-axis as shown in the figure. At $t = 0$ it begins to accelerate with an acceleration that depends on time according to the formula $a(t) = a_1 - a_2 t$, where a_1 and a_2 are constants. If $a_1 = 4$ m/s^2 and $a_2 = 2$ m/s^3, at what time t (in s) does the car return to its starting point?



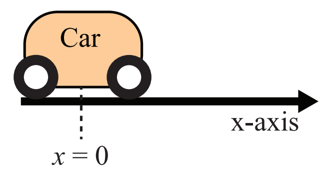
(1) 6 (2) 9 (3) 12 (4) 3 (5) 16

26. An automobile starts from rest on the x-axis as shown in the figure. At $t = 0$ it begins to accelerate with an acceleration that depends on time according to the formula $a(t) = a_1 - a_2 t$, where a_1 and a_2 are constants. If $a_1 = 6$ m/s^2 and $a_2 = 2$ m/s^3, at what time t (in s) does the car return to its starting point?



(1) 9 (2) 6 (3) 12 (4) 3 (5) 16

27. An automobile starts from rest on the x-axis as shown in the figure. At $t = 0$ it begins to accelerate with an acceleration that depends on time according to the formula $a(t) = a_1 - a_2 t$, where a_1 and a_2 are constants. If $a_1 = 8$ m/s^2 and $a_2 = 2$ m/s^3, at what time t (in s) does the car return to its starting point?



(1) 12 (2) 6 (3) 9 (4) 3 (5) 16

28. Two loud speakers are located 4 m apart on an outdoor stage. A listener is 18 m from one and 21 m from the other. During the sound check, a signal generator drives the two speakers in phase with the same amplitude and frequency. The transmitted frequency is swept through the audible range (20 Hz to 20 kHz). What is the lowest frequency (in Hz) that gives minimum signal (maximum destructive interference) at the listener's location? (Take the speed of sound to be 343 m/s.)

(1) 57.2 (2) 85.8 (3) 171.5 (4) 114.3 (5) 343.0

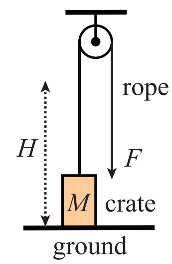
29. Two loud speakers are located 3 m apart on an outdoor stage. A listener is 19 m from one and 21 m from the other. During the sound check, a signal generator drives the two speakers in phase with the same amplitude and frequency. The transmitted frequency is swept through the audible range (20 Hz to 20 kHz). What is the lowest frequency (in Hz) that gives minimum signal (maximum destructive interference) at the listener's location? (Take the speed of sound to be 343 m/s.)

(1) 85.8 (2) 57.2 (3) 171.5 (4) 114.3 (5) 343.0

30. Two loud speakers are located 3 m apart on an outdoor stage. A listener is 20 m from one and 21 m from the other. During the sound check, a signal generator drives the two speakers in phase with the same amplitude and frequency. The transmitted frequency is swept through the audible range (20 Hz to 20 kHz). What is the lowest frequency (in Hz) that gives minimum signal (maximum destructive interference) at the listener's location? (Take the speed of sound to be 343 m/s.)

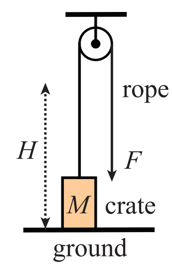
(1) 171.5 (2) 57.2 (3) 85.8 (4) 114.3 (5) 343.0

31. Near the surface of the Earth, a student is using a simple pulley to lift a crate of mass $M = 30$ kg from rest to a height H by pulling on the rope with a constant force F as shown in the figure. If the breaking strength of the rope is 500 N, what is the minimum time (in s) required for the student to haul the crate to a height $H = 20$ m? (Assume that the pulley is massless and frictionless.)



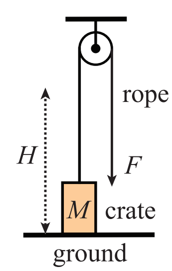
(1) 2.4
(2) 3.0
(3) 3.8
(4) 1.6
(5) 5.2

32. Near the surface of the Earth, a student is using a simple pulley to lift a crate of mass $M = 35$ kg from rest to a height H by pulling on the rope with a constant force F as shown in the figure. If the breaking strength of the rope is 500 N, what is the minimum time (in s) required for the student to haul the crate to a height $H = 20$ m? (Assume that the pulley is massless and frictionless.)



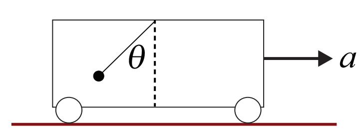
(1) 3.0
(2) 2.4
(3) 3.8
(4) 1.6
(5) 5.2

33. Near the surface of the Earth, a student is using a simple pulley to lift a crate of mass $M = 40$ kg from rest to a height H by pulling on the rope with a constant force F as shown in the figure. If the breaking strength of the rope is 500 N, what is the minimum time (in s) required for the student to haul the crate to a height $H = 20$ m? (Assume that the pulley is massless and frictionless.)



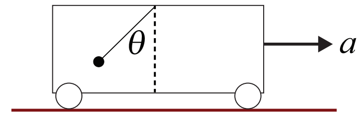
(1) 3.8
(2) 2.4
(3) 3.0
(4) 1.6
(5) 5.2

34. Consider a mass $M = 20$ kg suspended by a very light string from the ceiling of a railway car near the surface of the Earth. The car has a constant acceleration as shown in the figure, causing the mass to hang at an angle θ with the vertical. If the acceleration of the railway car is $a = 10\ \mathrm{m/s^2}$, what is the tension in the string (in N)?



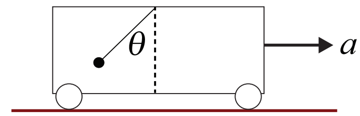
(1) 280.0 (2) 420.0 (3) 560.1 (4) 196.0 (5) 294.0

35. Consider a mass $M = 30$ kg suspended by a very light string from the ceiling of a railway car near the surface of the Earth. The car has a constant acceleration as shown in the figure, causing the mass to hang at an angle θ with the vertical. If the acceleration of the railway car is $a = 10$ m/s^2, what is the tension in the string (in N)?



(1) 420.0 (2) 280.0 (3) 560.1 (4) 196.0 (5) 294.0

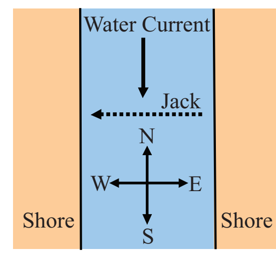
36. Consider a mass $M = 40$ kg suspended by a very light string from the ceiling of a railway car near the surface of the Earth. The car has a constant acceleration as shown in the figure, causing the mass to hang at an angle θ with the vertical. If the acceleration of the railway car is $a = 10$ m/s^2, what is the tension in the string (in N)?



(1) 560.1 (2) 280.0 (3) 420.0 (4) 196.0 (5) 392.0

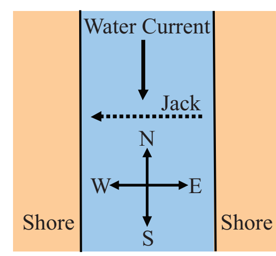
37. Jack wants to row directly across a river from the east shore to a point on the west shore, as shown in the figure. The width of the river is 250 m and the current flows from north to south at 0.5 m/s. The trip takes Jack 4 minutes. At what speed (in m/s) with respect to the still water is Jack able to row?

(1) 1.16
(2) 1.48
(3) 2.14
(4) 1.04
(5) 0.86



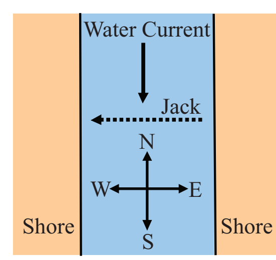
38. Jack wants to row directly across a river from the east shore to a point on the west shore, as shown in the figure. The width of the river is 250 m and the current flows from north to south at 0.5 m/s. The trip takes Jack 3 minutes. At what speed (in m/s) with respect to the still water is Jack able to row?

(1) 1.48
(2) 1.16
(3) 2.14
(4) 1.39
(5) 0.86

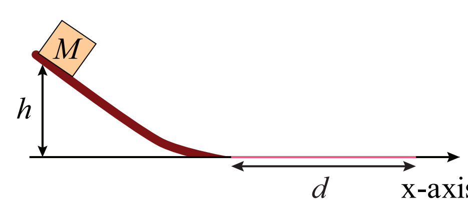


39. Jack wants to row directly across a river from the east shore to a point on the west shore, as shown in the figure. The width of the river is 250 m and the current flows from north to south at 0.5 m/s. The trip takes Jack 2 minutes. At what speed (in m/s) with respect to the still water is Jack able to row?

(1) 2.14
(2) 1.16
(3) 1.48
(4) 2.08
(5) 0.86

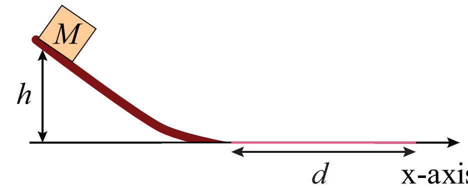


40. Near the surface of the Earth a block of mass M is released from rest at a height H on a frictionless incline as shown in the figure. The block slides down the frictionless incline to reach a flat horizontal surface with kinetic coefficient of friction $\mu_k = 0.2$. If the block slides a horizontal distance $d = 25$ m along the surface before coming to rest, what is the initial height H (in m)?



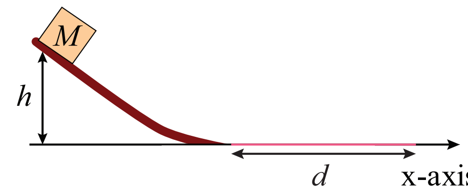
(1) 5 (2) 10 (3) 15 (4) 20 (5) 25

41. Near the surface of the Earth a block of mass M is released from rest at a height H on a frictionless incline as shown in the figure. The block slides down the frictionless incline to reach a flat horizontal surface with kinetic coefficient of friction $\mu_k = 0.4$. If the block slides a horizontal distance $d = 25$ m along the surface before coming to rest, what is the initial height H (in m)?



(1) 10 (2) 5 (3) 15 (4) 20 (5) 25

42. Near the surface of the Earth a block of mass M is released from rest at a height H on a frictionless incline as shown in the figure. The block slides down the frictionless incline to reach a flat horizontal surface with kinetic coefficient of friction $\mu_k = 0.6$. If the block slides a horizontal distance $d = 25$ m along the surface before coming to rest, what is the initial height H (in m)?



(1) 15 (2) 5 (3) 10 (4) 20 (5) 25

43. At what two distances from the center of the Earth, r, is the gravitational force on a point mass m equal to 1/4 of what it is at the surface of the Earth? (Note: R_E is the radius of the Earth.)

(1) $2R_E$ and $R_E/4$ (2) $3R_E$ and $R_E/9$ (3) $4R_E$ and $R_E/16$ (4) $4R_E$ and $R_E/4$ (5) $2R_E$ and $R_E/2$

44. At what two distances from the center of the Earth, r, is the gravitational force on a point mass m equal to 1/9 of what it is at the surface of the Earth? (Note: R_E is the radius of the Earth.)

(1) $3R_E$ and $R_E/9$ (2) $2R_E$ and $R_E/4$ (3) $4R_E$ and $R_E/16$ (4) $3R_E$ and $R_E/3$ (5) $9R_E$ and $R_E/9$

45. At what two distances from the center of the Earth, r, is the gravitational force on a point mass m equal to 1/16 of what it is at the surface of the Earth? (Note: R_E is the radius of the Earth.)

(1) $4R_E$ and $R_E/16$ (2) $2R_E$ and $R_E/4$ (3) $3R_E$ and $R_E/9$ (4) $4R_E$ and $R_E/4$ (5) $16R_E$ and $R_E/16$

46. Planet Roton, with a mass of 7×10^{24} kg and a radius of 1,500 km, gravitationally attracts a meteorite that is initially at rest relative to the planet, at a distance great enough to take as infinite. The meteorite falls toward the planet. Assuming the planet is airless, what is the speed (in km/s) of the meteorite relative to the planet when it reaches the planet's surface?

(1) 25.0 (2) 17.6 (3) 14.4 (4) 31.2 (5) 11.6

47. Planet Roton, with a mass of 7×10^{24} kg and a radius of 3,000 km, gravitationally attracts a meteorite that is initially at rest relative to the planet, at a distance great enough to take as infinite. The meteorite falls toward the planet. Assuming the planet is airless, what is the speed (in km/s) of the meteorite relative to the planet when it reaches the planet's surface?

(1) 17.6 (2) 25.0 (3) 14.4 (4) 31.2 (5) 11.6

48. Planet Roton, with a mass of 7×10^{24} kg and a radius of 4,500 km, gravitationally attracts a meteorite that is initially at rest relative to the planet, at a distance great enough to take as infinite. The meteorite falls toward the planet. Assuming the planet is airless, what is the speed (in km/s) of the meteorite relative to the planet when it reaches the planet's surface?

(1) 14.4 (2) 25.0 (3) 17.6 (4) 31.2 (5) 11.6

49. What is the maximum total mass of the cargo (including the mass of the empty balloon) that a spherical helium balloon with a radius of 4.0 m can lift off the ground? The density of helium and the air are $\rho_{\mathrm{He}} = 0.18$ kg/m^3 and $\rho_{\mathrm{air}} = 1.2$ kg/m^3, respectively. Assume that the density of the cargo is much larger than the density of the air.

(1) 273.4 kg (2) 534.1 kg (3) 922.9 kg (4) 175.5 kg (5) 1020.2 kg

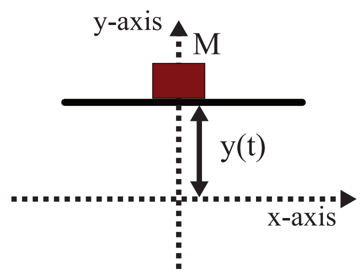
50. What is the maximum total mass of the cargo (including the mass of the empty balloon) that a spherical helium balloon with a radius of 5.0 m can lift off the ground? The density of helium and the air are $\rho_{\mathrm{He}} = 0.18$ kg/m^3 and $\rho_{\mathrm{air}} = 1.2$ kg/m^3, respectively. Assume that the density of the cargo is much larger than the density of the air.

(1) 534.1 kg (2) 273.4 kg (3) 922.9 kg (4) 175.5 kg (5) 1020.2 kg

51. What is the maximum total mass of the cargo (including the mass of the empty balloon) that a spherical helium balloon with a radius of 6.0 m can lift off the ground? The density of helium and the air are $\rho_{\mathrm{He}} = 0.18$ kg/m^3 and $\rho_{\mathrm{air}} = 1.2$ kg/m^3, respectively. Assume that the density of the cargo is much larger than the density of the air.

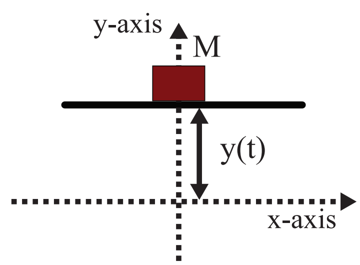
(1) 922.9 kg (2) 273.4 kg (3) 534.1 kg (4) 175.5 kg (5) 1020.2 kg

52. Near the surface of the Earth, a flat platform is undergoing simple harmonic motion and is oscillating vertically, up and down according to the formula $y(t) = A\sin(\omega t)$ as shown in the figure. A block of mass M sits on a platform, but the block is not attached to the platform. The angular frequency ω of the oscillations starts out small and increases slowly. If the amplitude of the oscillations is $A = 2.45$ m, at what value of ω (in rad/s) does the block lose contact with the platform and start to bounce?



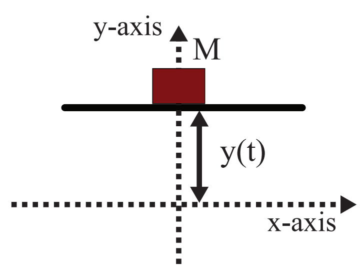
(1) 2.0 (2) 1.0 (3) 0.5 (4) 2.5 (5) 4.0

53. Near the surface of the Earth, a flat platform is undergoing simple harmonic motion and is oscillating vertically, up and down according to the formula $y(t) = A\sin(\omega t)$ as shown in the figure. A block of mass M sits on a platform, but the block is not attached to the platform. The angular frequency ω of the oscillations starts out small and increases slowly. If the amplitude of the oscillations is $A = 9.8$ m, at what value of ω (in rad/s) does the block lose contact with the platform and start to bounce?



(1) 1.0 (2) 2.0 (3) 0.5 (4) 2.5 (5) 4.0

54. Near the surface of the Earth, a flat platform is undergoing simple harmonic motion and is oscillating vertically, up and down according to the formula $y(t) = A\sin(\omega t)$ as shown in the figure. A block of mass M sits on a platform, but the block is not attached to the platform. The angular frequency ω of the oscillations starts out small and increases slowly. If the amplitude of the oscillations is $A = 39.2$ m, at what value of ω (in rad/s) does the block lose contact with the platform and start to bounce?



(1) 0.5 (2) 2.0 (3) 1.0 (4) 2.5 (5) 4.0

55. An ideal spring-and-mass system is undergoing simple harmonic motion (SHM) with a period of the oscillations $T = 2$ s. If the speed of the block is 1.0 m/s when the displacement from equilibrium is 2.0 m, what is the speed of the block (in m/s) when the displacement from equilibrium is 1.0 m?

(1) 5.5 (2) 3.8 (3) 2.9 (4) 6.2 (5) 1.9

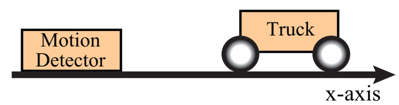
56. An ideal spring-and-mass system is undergoing simple harmonic motion (SHM) with a period of the oscillations $T = 3$ s. If the speed of the block is 1.0 m/s when the displacement from equilibrium is 2.0 m, what is the speed of the block (in m/s) when the displacement from equilibrium is 1.0 m?

(1) 3.8 (2) 5.5 (3) 2.9 (4) 6.2 (5) 1.9

57. An ideal spring-and-mass system is undergoing simple harmonic motion (SHM) with a period of the oscillations $T = 4$ s. If the speed of the block is 1.0 m/s when the displacement from equilibrium is 2.0 m, what is the speed of the block (in m/s) when the displacement from equilibrium is 1.0 m?

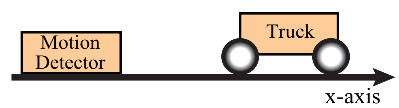
(1) 2.9 (2) 5.5 (3) 3.8 (4) 6.2 (5) 1.9

58. A stationary motion detector on the x-axis sends sound waves of frequency 500 Hz, as shown in the figure. The waves sent out by the detector are reflected off a truck traveling along the x-axis and then are received back at the detector. If the frequency of the waves received back at the detector is 400 Hz, what is the x-component of the velocity of the truck (in m/s)? (Take the speed of sound to be 343 m/s.)



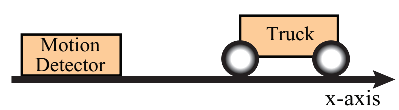
(1) 38.1 (2) −68.6 (3) 60.5 (4) 90.3 (5) −38.1

59. A stationary motion detector on the x-axis sends sound waves of frequency 500 Hz, as shown in the figure. The waves sent out by the detector are reflected off a truck traveling along the x-axis and then are received back at the detector. If the frequency of the waves received back at the detector is 750 Hz, what is the x-component of the velocity of the truck (in m/s)? (Take the speed of sound to be 343 m/s.)



(1) −68.6 (2) 38.1 (3) 60.5 (4) 68.6 (5) −38.1

60. A stationary motion detector on the x-axis sends sound waves of frequency 500 Hz, as shown in the figure. The waves sent out by the detector are reflected off a truck traveling along the x-axis and then are received back at the detector. If the frequency of the waves received back at the detector is 350 Hz, what is the x-component of the velocity of the truck (in m/s)? (Take the speed of sound to be 343 m/s.)



(1) 60.5 (2) 38.1 (3) −68.6 (4) 90.3 (5) −60.5

FOLLOWING GROUPS OF QUESTIONS WILL BE SELECTED AS ONE GROUP FROM EACH TYPE
TYPE 1
Q# S 1
Q# S 2
Q# S 3
TYPE 2
Q# S 4
Q# S 5
Q# S 6
TYPE 3
Q# S 7
Q# S 8
Q# S 9
TYPE 4

Q# S 10
Q# S 11
Q# S 12
TYPE 5
Q# S 13
Q# S 14
Q# S 15
TYPE 6
Q# S 16
Q# S 17
Q# S 18
TYPE 7
Q# S 19
Q# S 20
Q# S 21
TYPE 8
Q# S 22
Q# S 23
Q# S 24
TYPE 9
Q# S 25
Q# S 26
Q# S 27
TYPE 10
Q# S 28
Q# S 29
Q# S 30
TYPE 11
Q# S 31
Q# S 32
Q# S 33
TYPE 12
Q# S 34
Q# S 35
Q# S 36
TYPE 13
Q# S 37
Q# S 38
Q# S 39
TYPE 14
Q# S 40
Q# S 41
Q# S 42
TYPE 15
Q# S 43
Q# S 44
Q# S 45
TYPE 16
Q# S 46
Q# S 47
Q# S 48
TYPE 17
Q# S 49
Q# S 50
Q# S 51
TYPE 18
Q# S 52
Q# S 53
Q# S 54
TYPE 19
Q# S 55
Q# S 56
Q# S 57
TYPE 20
Q# S 58
Q# S 59
Q# S 60