Instructor(s):

PHY 2048 PHYSICS DEPARTMENT
Final Exam April 28, 2007

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 <u>blue</u> or <u>black</u> 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.**

$g = 10\ \text{m/s}^2$	1 mile = 1.6 km	1 hour = 3600 seconds	nano: $\text{n} = 10^{-9}$
micro: $\mu = 10^{-6}$	milli: $\text{m} = 10^{-3}$	centi: $\text{c} = 10^{-2}$	kilo: $\text{k} = 10^3$
mega: $\text{M} = 10^6$	giga: $\text{G} = 10^9$	terra: $\text{T} = 10^{12}$	$G = 6.673 \times 10^{-11}\text{Nm}^2/\text{kg}^2$
Area of a circle with radius R: πR^2		Volume of a sphere with radius R: $\frac{4\pi}{3}R^3$	
Moment of inertia of a rod of length L and mass M rotating about an axis perpendicular to the rod and going through its center: $I = \frac{1}{12}mL^2$			

1. A key falls from a bridge that is 30 m above the water. It falls directly into a model boat moving at constant velocity that was 10 m from the point of impact when the key was released. What is the speed of the boat?

(1) 4.1 m/s (2) 41 m/s (3) 24.5 m/s (4) 2.45 m/s (5) 1.7 m/s

2. An explorer needs to travel 5.6 km due North to reach her base camp. While caught in a snow storm, she actually travels 7.8 km at 50° South of due East. How far must she now travel to reach her base camp?

(1) 12.6 km (2) 12.2 km (3) 6.0 km (4) 2.2 km (5) 13.4 km

3. Your friend drops a stone from a cliff of height $h = 500$ m with zero initial velocity. You throw your stone 2 s later. At what minimum velocity pointing downward do you need to throw your stone so that it hits the ground first?

(1) 22.5 m/s (2) 18.3 m/s (3) 16.0 m/s (4) 12.1 m/s (5) 8.7 m/s

4. Jane, with mass 50 kg, stands in a canoe and pulls on a rope that Tarzan, with mass 100 kg, has tied to his canoe. Tarzan accelerates with a magnitude of 2 m/s^2 with respect to water. What is the magnitude of Jane's acceleration (in m/s^2) *with respect to Tarzan*? The canoes have no mass and no friction with the water.

(1) 6.0 (2) 4.0 (3) 8.0 (4) $5\sqrt{2}$ (5) $2\sqrt{5}$

5. A block of mass $m = 1$ kg is dropped from rest onto a spring with $k = 400$ N/m. The spring is compressed a distance $x = 0.1$ m when the block stops for an instant. How far did the block fall before it hit the spring?

(1) 0.1 m (2) 0.2 m (3) 0.5 m (4) 0.4 m (5) 0.3 m

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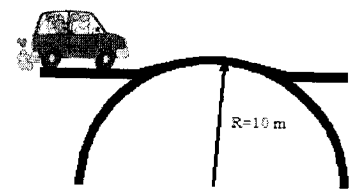
6. A student in a physics lab is measuring the acceleration of objects sliding down an incline at an angle θ with the horizontal. He finds that the acceleration is half of what he calculates in assumption of no friction. What is the value of the coefficient of kinetic friction?

(1) $\frac{1}{2}\tan\theta$ (2) $2\tan\theta$ (3) $1/2$ (4) $2\cos\theta$ (5) $2\sin\theta$

7. A body of mass 3.0 kg makes an elastic collision with another body at rest and continues to move in the original direction, but with one-half of its original speed. What is the mass of the other body?

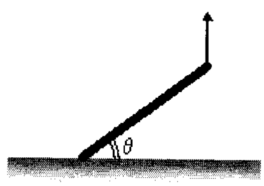
(1) 1.0 kg (2) 1.5 kg (3) 2.0 kg (4) 1.7 kg (5) 2.1 kg

8. A car approaches a bulge on a road with a radius of curvature at its top portion R=10 m, as shown in the figure. What is the maximum speed at which the car can pass the bump without losing traction with the road (i.e. without jumping)? Assume that the car has a constant speed with respect to the road surface.



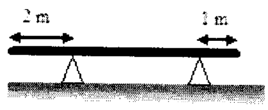
(1) 22.5 mph (2) 20.0 mph (3) 25.0 mph (4) 27.5 mph (5) 30.0 mph

9. A meterstick of mass m=3 kg and length L=1 m leans at an angle $\theta = 37°$ from the horizontal and is held up by a vertical string, shown in the figure. What is the tension in the string?



(1) 15 N (2) 20 N (3) 25 N (4) 30 N (5) 35 N

10. A 6 m long plank has a mass of 6 kg. It rests on two supports as shown in the figure. How much force is applied to the left support?



(1) 40 N (2) 30 N (3) 20 N (4) 10 N (5) 60 N

11. Jupiter is 5.2 times farther from than the Sun than the Earth. What is the Jovian year (in Earth years) ?

(1) 11.9 (2) 3.0 (3) 2.3 (4) 5.2 (5) 27.0

12. It is known that Earth is 80 times more massive than the moon, the radius of Earth is 3.66 times the radius of the moon and the distance between Earth and moon is approximately 60 times the radius of the Earth R. There is a point P in between Earth and moon where the net gravitational field vanishes. What is the distance of this point P from the center of Earth (in terms of radius of Earth R)?

(1) 54 R (2) 42 R (3) 36 R (4) 48 R (5) 30 R

13. On a planet of average density 5.52×10^3 kg /m^3, the acceleration due to gravity on the surface is measured to be 4.9 m/s^2. What is the radius of this planet (in meters)? Note: mass of Earth $M = 5.98 \times 10^{24}$ kg and radius of Earth $R = 6.37 \times 10^6$ m.

(1) 3.18×10^6 (2) 1.59×10^6 (3) 6.34×10^6 (4) 4.77×10^6 (5) 2.39×10^6

14. An intrepid physicist is in search of the ultimate thrill. She digs a hole straight through the earth (along a diameter) and jumps in. She falls through the center of the earth until reaching the other side, whereupon the force of gravity pulls her back through the earth to her starting point, where she has a group of friends waiting to catch her (and thus prevent her from participating in simple harmonic motion indefinitely). If we assume the earth is a sphere of uniform density with radius $R = 6.37 \times 10^6$ m and mass $M = 5.98 \times 10^{24}$ kg, then what is the period of her motion? (HINT: What is the force due to gravity on the physicist as a function of r, where r is her distance from the center of the earth?)

(1) 84 minutes (2) 42 minutes (3) 21 minutes (4) 10 minutes (5) 168 minutes

15. A mass of 2 kg connected to a spring which is connected to the ceiling oscillates with a period of 6.3 s. If the maximal kinetic energy during these oscillations is 0.25 J, then what is the amplitude of the motion?

(1) 0.5 m (2) 0.2 m (3) 1 m (4) 0.13 m (5) 0.25 m

16. A physical pendulum consists of a uniform rod of length L (in meters), suspended from one end. If the pendulum oscillates with a period T (in seconds), then what is the acceleration of gravity, g, at the location of the pendulum in terms of T and L?

(1) $\frac{8\pi^2 L}{3T^2}$ (2) $\frac{8\pi^2 T}{3L^2}$ (3) $\frac{2\pi^2 L}{3T^2}$ (4) $\frac{2\pi^2 T}{3L^2}$ (5) $\frac{4\pi^2 L}{3T^2}$

17. It is known that our sun undergoes some mode of oscillation. Assuming that these oscillations are due to the force of gravity alone, and given that $M_{\text{sun}} = 1.99 \times 10^{30}$ kg and $R_{\text{sun}} = 6.96 \times 10^8$ m, use dimensional arguments to estimate the frequency of such an oscillation.

(1) ~ 1 mHz (2) ~ 1 Hz (3) ~ 1 μHz (4) ~ 1 kHz (5) ~ 1 MHz

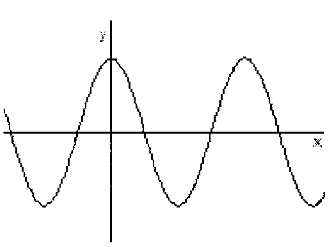
18. A piano string is 0.5 m long and the fundamental mode of oscillation has a frequency of $f = 300$ Hz. What is the speed of a wave down the piano string?

(1) 300 m/s (2) 150 m/s (3) 600 m/s (4) 900 m/s (5) 100 m/s

19. The frequency of the fundamental oscillation mode of a string is f. What would this frequency be for a string made of the same material, being same length, twice thicker, and stretched at twice the tension?

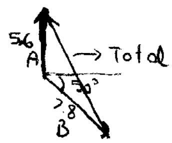
(1) $f/\sqrt{2}$ (2) f (3) $f\sqrt{2}$ (4) $2f$ (5) $f/2$

20. A wave traveling down a rope is described mathematically by $y = A\sin(kx - \omega t)$. The period of the wave oscillation is $T = 2\pi/\omega$. A picture of the wave at some particular time is shown in the figure. At which of the following times might the picture have been taken?



(1) $\frac{3T}{4}$ (2) $\frac{T}{4}$ (3) $\frac{T}{2}$ (4) T (5) 0

[1] $30m = \Delta h \Rightarrow \Delta h = \frac{1}{2}gt^2 \Rightarrow t^2 = \frac{2\Delta h}{g} = \frac{60}{10} = 6$ Along $x \Rightarrow \Delta x = v_x t \Rightarrow v_x = \frac{\Delta x}{t} = \frac{10}{\sqrt{6}} \simeq 4.1 m/s$

[2] 

$\Rightarrow |Total| = \sqrt{[5.6 + 7.8\sin 50°]^2 + [7.8\cos 50°]^2} \simeq 12.6$

Total y-component x-component

[3] For the first stone

$h = \frac{1}{2}gt^2 \Rightarrow t = \sqrt{\frac{2h}{g}} = \sqrt{\frac{2\times 500}{10}} = 10s.$ ∴ Total time for the second is $8s \Rightarrow \Delta y = v_0 t + \frac{1}{2}gt^2$

$500 = v_0 \times 8 + \frac{1}{2}\times 10 \times 8^2 \Rightarrow v_0 = 22.5$

[4] $F = m_T a_T = m_J a_J \Rightarrow a_J = \frac{m_T}{m_J} a_T = \frac{100}{50}\times 2 = 4 m/s^2$ Jane $\xrightarrow{4 m/s^2}$ Tarzan $\xleftarrow{2 m/s^2}$ $\Rightarrow a_{J-T} = 4-(-2) = 6 \; m/s^2$

[5] $E_i = E_f \Rightarrow mg(h+x) = \frac{1}{2}kx^2 \Rightarrow 1\times 10(h+0.1) = \frac{1}{2}\times 400\times(0.1)^2 \Rightarrow 10h + 1 = 2 \Rightarrow h = 0.1 m$

[6] without friction $a = g\sin\theta$ with friction $a = g\sin\theta - \mu g\cos\theta \Rightarrow \frac{1}{2}g\sin\theta = g\sin\theta - \mu g\cos\theta \Rightarrow \mu g\cos\theta = \frac{1}{2}g\sin\theta$

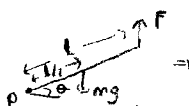
$\therefore \mu = \frac{1}{2}\tan\theta$

[7] $P_i = P_f \Rightarrow m_1 v = m_1\frac{v}{2} + m_2 v' \Rightarrow v' = \frac{m_1}{m_2}\frac{v}{2}$

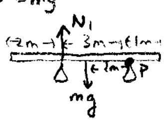
$E_i = E_f \Rightarrow \frac{1}{2}m_1 v^2 = \frac{1}{2}m_1\left(\frac{v}{2}\right)^2 + \frac{1}{2}m_2 v'^2 \Rightarrow \frac{3}{4}m_1 v^2 = m_2 v'^2 = m_2\left[\frac{m_1}{m_2}\frac{v}{2}\right]^2 \Rightarrow \frac{3}{4}m_1 v^2 = \frac{1}{4}\frac{m_1^2}{m_2}v^2 \Rightarrow m_1 = 3m_2$

$\therefore m_2 = 1kg$

[8] $mgh = \frac{mv^2}{R} \Rightarrow v = \sqrt{gR} = 10 m/s \cong 22.5$ mph

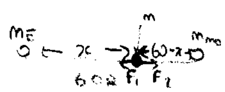
[9] 

$\Rightarrow \Sigma\vec{\tau}_p = 0 \Rightarrow F\times l\cos\theta - mg\times\frac{l}{2}\cos\theta = 0 \Rightarrow F = \frac{mg}{2} \Rightarrow |\vec{F}| = 15N$

[10] 

$\Sigma\vec{\tau}_p = 0 \Rightarrow -3N_1 + 2mg = 0 \Rightarrow N_1 = \frac{2}{3}mg = 40 N$

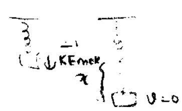
[11] $T^2 = const\; R^3 \Rightarrow const = \frac{T_E^2}{R_E^3} = \frac{T_J^2}{R_J^3} \Rightarrow T_J = T_E\left(\frac{R_J}{R_E}\right)^{3/2} = 11.9\; T_E$

[12] 

$F_1 = F_2 \Rightarrow G\frac{m_E m}{x^2} = G\frac{m_{mo} m}{(60-x)^2} \Rightarrow \frac{m_E}{m_{mo}} = \left(\frac{x}{60-x}\right)^2 \Rightarrow \frac{x}{60-x} = 80 \Rightarrow x = 54$

[13] $mg = G\frac{Mm}{R^2}$; $M = \rho V = \rho\times\frac{4\pi}{3}R^3 \Rightarrow mg = G\frac{Mm}{R^2} = \frac{Gm}{R^2}\times\frac{4\pi}{3}\rho R^3 \therefore R = \frac{3g}{4\pi\rho G} = \frac{3\times 4.9}{4\pi\times 5.5\times 10^3\times 6.67\times 10^{-11}} = 3.18\times 10^6 m$

[14] $a = \frac{d^2x}{dt^2} \Rightarrow |a| = \frac{GM_{in}}{r^2} = \frac{GM_{Tot}}{R^3}r \Rightarrow \frac{d^2r}{dt^2} + \frac{GM_T}{R^3}r = 0 \Rightarrow \omega = \sqrt{\frac{GM}{R^3}} \Rightarrow T = \frac{2\pi}{\omega} \Rightarrow T = 2\pi\sqrt{\frac{R^3}{GM}} = 84$ mins

[15] $T = 2\pi\sqrt{\frac{m}{k}} \Rightarrow k = \frac{4\pi^2 m}{T^2}$ and energy conservation 

$mgx + \frac{1}{2}mv^2 = \frac{1}{2}kx^2$

$0.25 J$

$\Rightarrow mgx + 0.25 = \frac{1}{2}\frac{4\pi^2 m}{T^2}x^2 \Rightarrow$ solving the quadratic eqn for $x \Rightarrow x = 0.5 m$

[16] $T = 2\pi\sqrt{\frac{I}{mgh}}$ $I = \frac{1}{3}mL^2$ and $h = L/2 \Rightarrow T = 2\pi\sqrt{\frac{1/3\, mL^2}{mg\, L/2}} \Rightarrow T = 2\pi\sqrt{\frac{2L}{3g}} \Rightarrow T^2 = 4\pi^2\frac{2l}{3g} \therefore g = \frac{8\pi^2 L}{3T^2}$

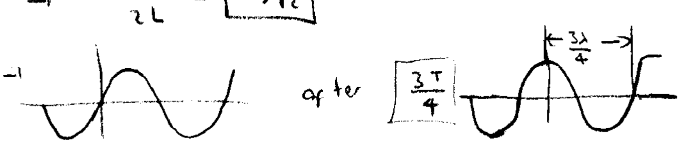
[17] $T = s \sim \sqrt{\frac{g}{L}}$ in terms of $G, M, R \Rightarrow T \sim \sqrt{\frac{GM_J}{R^3}} \sim 1 mHz$

[18] $F = n\frac{v}{2L} \Rightarrow$ fundamental $n=1 \Rightarrow v = 2L\times F = 2\times 0.5\times 300 = 300 m/s$

[19] $v = \sqrt{\frac{T}{\mu}}$ where T = tension ; μ = linear density  $\Rightarrow$ Twice thicker $\mu \to 4\mu$ $\therefore v \Rightarrow \sqrt{\frac{2T}{4\mu}} = \frac{v_0}{\sqrt{2}}$

$T \to 2T$

$\therefore F_0 = \frac{v_0}{2L} \Rightarrow \frac{v_0/\sqrt{2}}{2L} = F_0/\sqrt{2}$

[20] At $t=0 \Rightarrow$  after $\frac{3T}{4}$