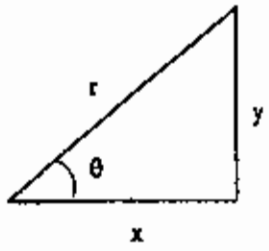
Physics 220 – Exam #2

March 29 **2004**

This exam consists of 12 problems on 7 pages. **Please check that you have them all.**

All of the formulas that you will need are given below. You may also use a calculator.



$\sin\theta = y/r$ $\cos\theta = x/r$ $\tan\theta = y/x$

average speed $= \frac{\text{distance traveled}}{\text{time}}$ $g = 9.8\ \text{m/s}^2$

average velocity $= \vec{v} = \frac{\text{displacement}}{\text{time}}$

instantaneous velocity = slope of position versus time
instantaneous acceleration = slope of velocity versus time

For constant acceleration:
$x = x_0 + v_0 t + \frac{1}{2}at^2$ $v = v_0 + at$ $v^2 = v_0^2 + 2a(x - x_0)$

$\vec{F} = m\vec{a}$ $F_{friction}^{max} = \mu_S N$ (static friction) $F_{friction} = \mu_K N$ (sliding friction)

$F_{gravity} = \frac{Gm_1m_2}{r^2}$ $G = 6.67 \times 10^{-11}\ \text{Nm}^2/\text{kg}^2$

$a_c = v^2/r$ $KE = \frac{1}{2}mv^2$ $W = F\,d\cos\theta$ $PE_{gravity} = mgh$

$W_{nc} = \Delta E$ power = work/Δt $\vec{p} = m\vec{v}$ Δp = impulse $= F\Delta t$

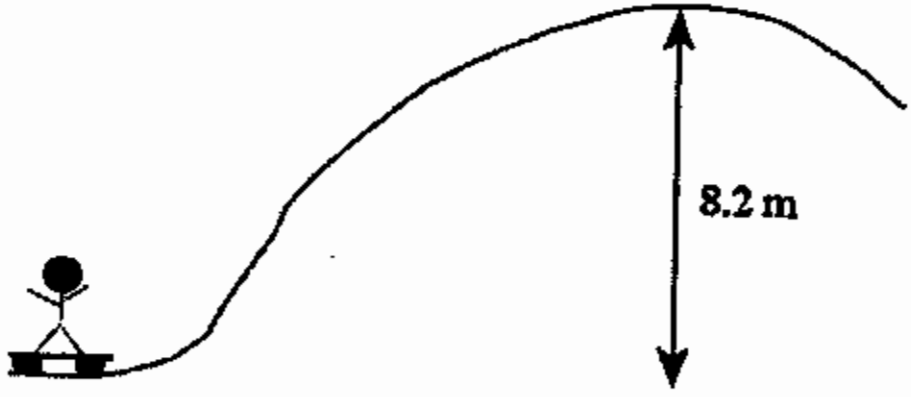
$KE = \frac{1}{2}I\omega^2$ $I = \Sigma mR^2$ τ = force × (lever arm) = Iα $L = I\omega$

$F_{spring} = -kx$ $PE_{spring} = \frac{1}{2}kx^2$ $\omega = 2\pi f$ $f = 1/T$

For constant angular acceleration:
$\theta = \theta_0 + \omega_0 t + \frac{1}{2}\alpha t^2$ $\omega = \omega_0 + \alpha t$ $\omega^2 = \omega_0^2 + 2\alpha(\theta - \theta_0)$

$\tau = I\alpha$ $\theta = s/r$ $\omega = v/r$ $\alpha = a/r$

1. It is your birthday and you received a new skateboard. This is not just any skateboard, but a special frictionless model. To test it you arrange to have a speed of 12 m/s on the approach to the ramp shown below. Do you make it to the top of the ramp, and if so, what is your speed when you get there?



a) You don't make it to the top.

b) You make it to the top, but your speed is zero when you get there.

c) You make it to the top, and your speed is13 m/s when you get there.

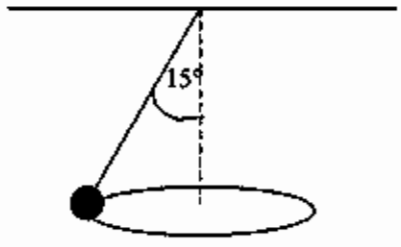
d) You make it to the top, and your speed is 4.1 m/s when you get there.

e) You make it to the top, and your speed is1.1 m/s when you get there.

2. A small coin is placed on a record that is rotating at 33.3 rpm (revolution per minute). If the coefficient of static friction between the coin and the record is 0.1, how far from the center of the record can the coin be placed without having it slip off?

a) 1.0 m
b) 0.28 m
c) 0.50 m
d) 2.1 m
e) 0.08 m

3. A rock of mass 3.0 kg is moving in uniform circular motion in a horizontal plane as shown in the figure. The radius of the orbit is 0.80 m. What is the linear speed (in m/s) of the rock?



a) 2.5

b) 1.4

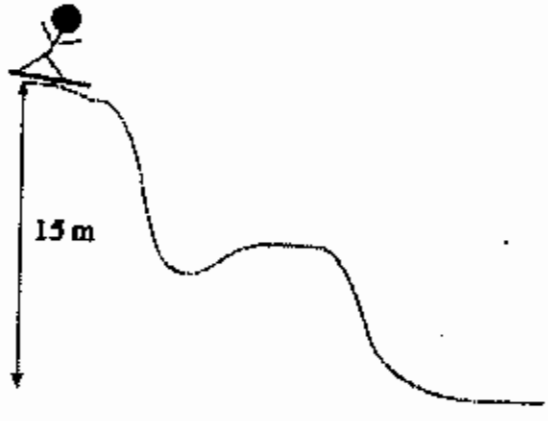
c) 2.8

d) 2.0

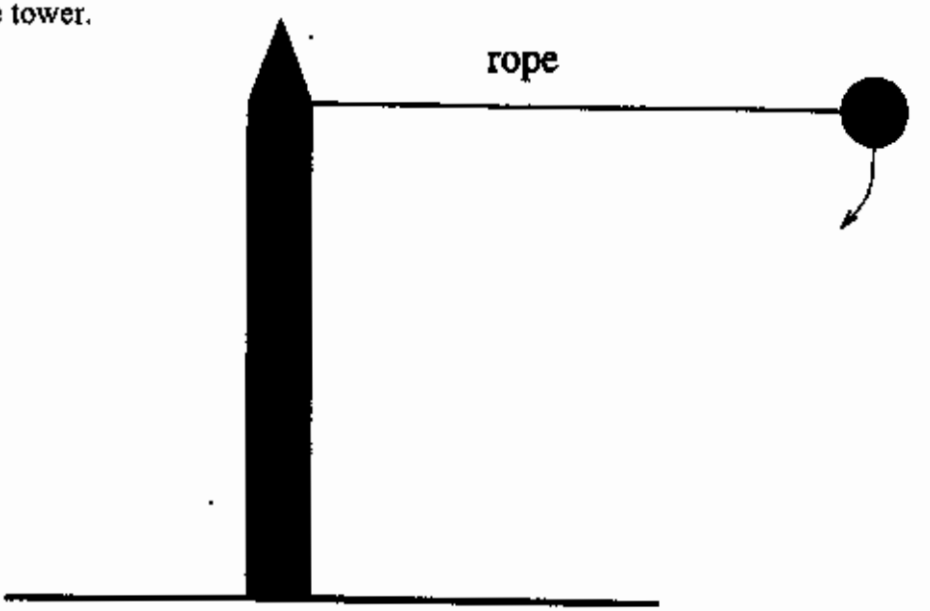
e) 9.8

4. A skier of mass 55 kg starts with an initial speed of 5.5 m/s at the top of a ski slope. When she reaches the bottom of the slope her speed is 9.0 m/s. How much work is done by friction and air drag on the skier?

a) +1400 J
b) −1400 J
c) −6700 J
d) −9500 J
e) 8100 J



5. A rock of mass m = 12 kg is tied to the end of a long rope of length L = 50 m. One end of the rope is tied to the top of the bell tower, and the rock is initially held with the rope horizontal as shown. The rock is then released and swings down to the bottom of the bell tower. Find the tension in the rope just before the rock hits the bottom of the tower.



a) 600 N
b) 350 N
c) 120 N
d) 240 N
e) 2.4 N

6. A satellite revolves about Earth in a circular orbit, with radius r_1 and speed v_1. A second satellite is in a circular orbit (r_2, v_2) around another planet, which has a mass four times that of Earth ($M = 4\ M_E$). If the two orbits have the same radius, $r_1 = r_2$, the speed of the second satellite (v_2) is:

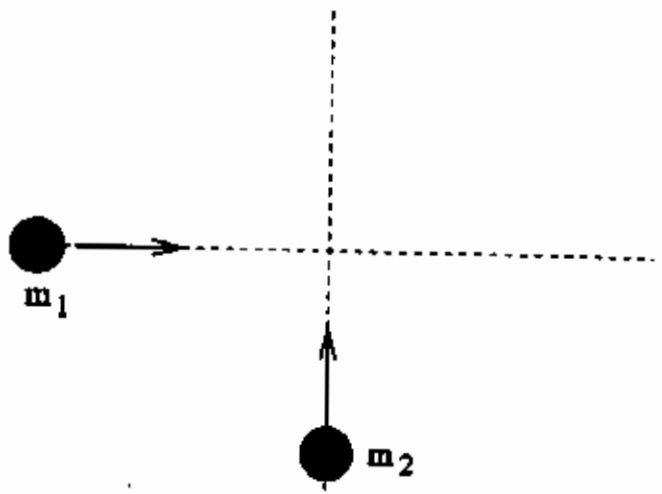
a) $v_2 = 2\ v_1$
b) $v_2 = 4v_1$
c) $v_2 = (1/2)\ v_1$
d) $v_2 = (1/4)\ v_1$
e) $v_2 = v_1$

7. Two cars are travelling along a straight level road on a collision course. A Ferrari (a sports car) of mass 1200 kg is traveling with a velocity of v = + 24 m/s. It collides with a 900 kg Honda (another car) going at v = – 42 m/s. After the collision the cars lock bumpers and move away together at a velocity v. Find v.

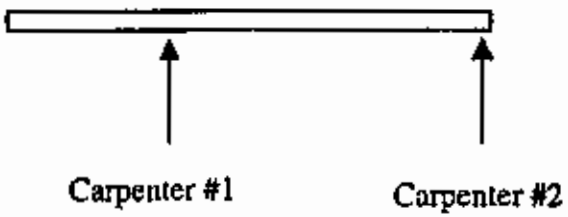
a) 18 m/s
b) 32 m/s
c) – 4.3 m/s
d) – 18 m/s
e) 62 m/s

8. Two asteroids (masses m_1 = 200 kg and m_2 = 300 kg) are moving on a collision course, and approach each other at right angles as shown. They collide and then stick together. Before the collision they have speeds v_1 = 20 m/s and v_2 = 11 m/s. What is their speed after the collision?

a) 8.0 m/s
b) 15 m/s
c) 1.4 m/s
d) 6.6 m/s
e) 10 m/s



9. Two carpenters are carrying a uniform beam. The beam is 2.44 m long and weighs 425 N. Carpenter #1 agrees to carry the beam 1.0 m from the end and the carpenter #2 carries the beam at its opposite end. What is the upward force (in Newtons) exerted on the beam by the first carpenter?



a) 213 N
b) 360 N
c) 65 N
d) 425 N
e) 125 N

10. A solid sphere of mass 1.0 kg rolls without slipping on a horizontal surface (without frictional loss of energy) with a translational speed of 10 m/s. What is the total energy of the rolling sphere? [$I = \frac{2}{5} MR^2$ for a solid sphere].

a) 50 J
b) 20 J
c) 100 J
d) 70 J
e) 40 J

11. A uniform rod of length L is free to pivot around an axis through its upper end. If it is released from rest when horizontal, at what speed is the lower end moving at its lowest point? [Hint: The gravitational potential energy change is determined by the change in height of the center of gravity. $I = \frac{1}{3}ML^2$ for a uniform rod.]

a) gL

b) $\sqrt{gL}$

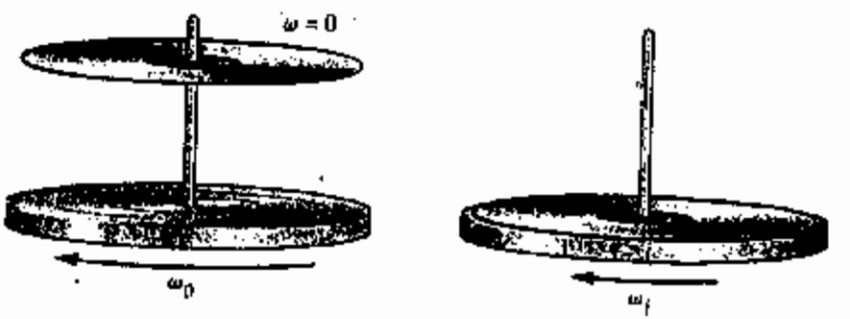
c) $\sqrt{2gL}$

d) $\sqrt{6gL}$

e) $\sqrt{3gL}$

12. A turntable for playing records has a moment of inertia of 5.2 kg m^2 and is rotating with an angular velocity of 36 rpm (revolutions per minute). A record, initially at rest, is dropped straight down onto the rotating turntable. The record and turntable rotate together at 33 rpm (revolutions per minute). Find the moment inertia of the record in kg m^2.

a) 0.47
b) 2.6
c) 5.7
d) 10.4
e) 0.13



Key to Exam #2, Physics 220

1. A
2. E
3. B
4. C
5. B
6. A
7. C
8. E
9. B
10. D
11. E
12. A