Key

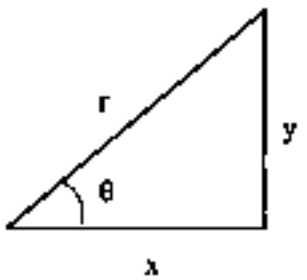
Physics 220 – Exam #1

September 13 **2001**

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

1 mile = 1.6 km

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

instantaneous velocity = slope of position versus time

instantaneous acceleration = slope of velocity versus time

For constant acceleration:

$x = x_0 + v_0 t + \frac{1}{2}at^2$

$v = v_0 + at$

$v^2 = v_0^2 + 2a(x - x_0)$

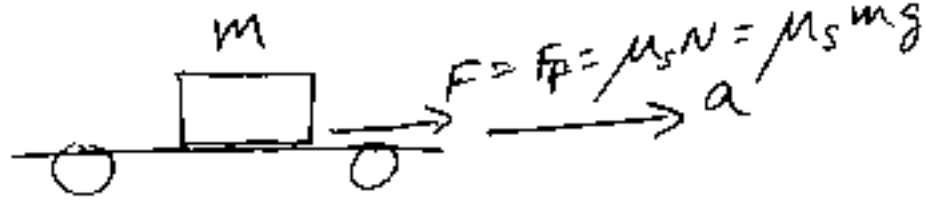
$\vec{F} = m\vec{a}$

$F_{friction}^{max} = \mu_S N$ (static friction) $F_{gravity} = \frac{Gm_1m_2}{r^2}$

$F_{friction} = \mu_K N$ (sliding friction)

1. A crate of mass $m = 2.5$ kg sits on the bed of a truck. The coefficient of static friction between the crate and the truck surface is μ_s, and the truck and the crate are initially at rest. The driver then begins to drive away, moving with a constant acceleration, but she is careful that the crate does not slide out of the truck. If the acceleration is 1.5 m/s^2, what is the minimum value of μ_s for which the crate will not slide? Assume that the surface of the truck is horizontal.

(a) 0.26
(b) 0.15
(c) 3.8
(d) 1.5
(e) 0.098



$F = ma$

$\mu_s mg = ma$

$\frac{a}{g} = \mu_s = \frac{1.5}{9.8} = 0.15$

2. A tennis ball is dropped from the top of the Purdue Bell tower. It takes 2.3 s for the ball to reach the ground. What is the height of the tower? Assume that the initial velocity of the ball is zero, and ignore air resistance.

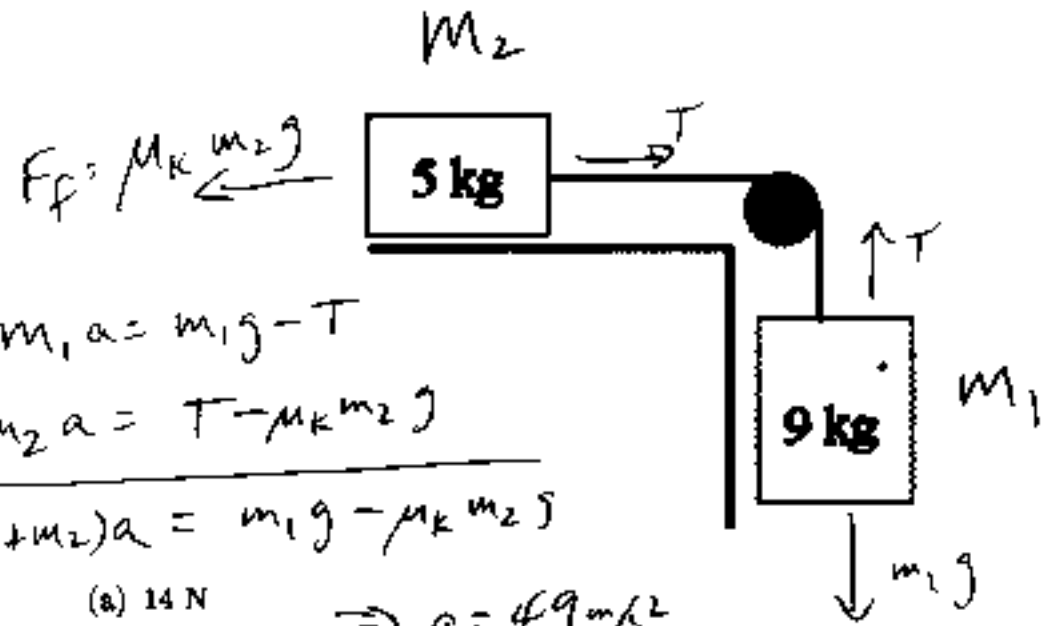
(a) 52 m
(b) 20 m
(c) 9.8 m
(d) 120 m
(e) 26 m

$y = y_0 + v_{y_0} t - \frac{1}{2} g t^2$

$0 = h + 0 - \frac{1}{2} g t^2$

$h = \frac{1}{2} g t^2 = \frac{1}{2}(9.8)\, 2.3^2 \cong 26\text{m}$

3. Two blocks are connected by a massless string which runs over a massless pulley as shown in the figure. The coefficient of kinetic friction between the 5 kg block and the table is $\mu_K = 0.40$. Find the tension in the string. Ignore air resistance.



$m_1 a = m_1 g - T$

$m_2 a = T - \mu_K m_2 g$

$(m_1 + m_2)a = m_1 g - \mu_K m_2 g$

$\Rightarrow a = 4.9\ m/s^2$

(a) 14 N
(b) 32 N
(c) 2.8 N
(d) 44 N
(e) 140 N

$T = m_1 g - m_1 a$

$= m_1 (g - a) = m_1 (9.8 - 4.9) = 44\ N$

4. A baseball of mass 0.20 kg which is initially at rest is hit by a baseball bat. If the bat and ball are in contact for a time 0.025 s and the speed of the ball just after it leaves the bat is 50 m/s, find the average force of the bat on the ball.

(a) 2.0 N
(b) 400 N
(c) 2000 N
(d) 10 N
(e) 120 N

$F_{ave} = m a_{ave}$

$= m \frac{\Delta v}{\Delta t} = 0.20 \frac{50 - 0}{0.025} = 400\ N$

5. A rock is thrown horizontally with an initial speed of 25 m/s off a bridge which is 75 m above the river which runs beneath it. Find the speed of the rock just before it hits the water below. Ignore the force of air resistance.

(a) 46 m/s
(b) 55 m/s
(c) 9.8 m/s
(d) 25 m/s
(e) 38 m/s

$v_x = 25\ m/s$

$v_y^2 = v_{y0}^2 + 2a_y(y - y_0)$

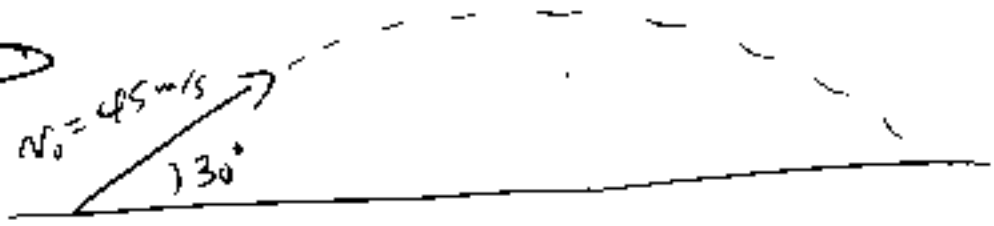
$= 0 - 2g(-75)$

$v_y^2 = 2(9.8)75 = 1470$

Speed $= v = \sqrt{v_x^2 + v_y^2} = \sqrt{25^2 + 1470} = 46\ m/s$

6. A baseball is hit with an initial speed of 45 m/s at an angle of 30° with respect to the horizontal. How far away from home plate does the ball land? For simplicity, assume that the ball starts at ground level. Ignore air resistance.

(a) 210 m
(b) 4.6 m
(c) 180 m
(d) 45 m
(e) 130 m



First find t to land

$y = y_0 + v_{y0}t - \frac{1}{2}gt^2$

$0 = 0 + v_0 \sin 30\, t - \frac{1}{2}gt^2 \Rightarrow t = \frac{2v_0 \sin 30}{g} = \frac{2 \cdot 45 \cdot \frac{1}{2}}{9.8}$

$x = \cancel{x_0}^{0} + v_{x0}t = \frac{v_0 \cos 30 \cdot 2 \cdot v_0 \sin 30}{g}$

$= \frac{45 \cdot \frac{\sqrt{3}}{2} \cdot 2 \cdot 45 \cdot \frac{1}{2}}{9.8}$

$= 179\ m$

7. In class we did a demonstration in which we "shot the monkey." Which of the following statements *best* describes the principle which this demonstration was designed to illustrate? For simplicity, assume that the force of air resistance is negligible.

   (a) For every force there is a reaction force.

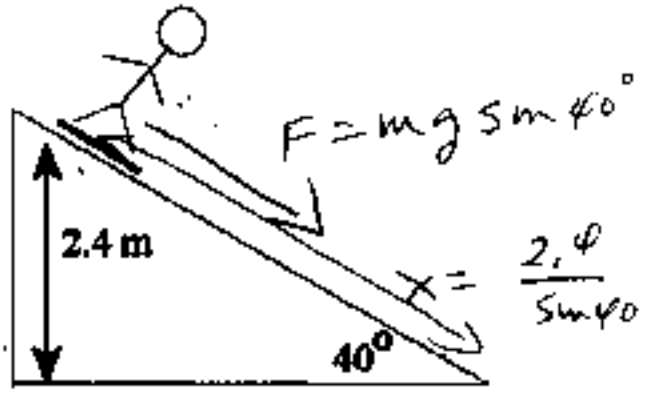
   (b) All objects feel the influence of gravity.

   (c) Velocity is the change of the position divided by the time.

   (d) All objects fall at the same rate, independent of their horizontal velocity.

   (e) Monkeys should not fall from trees.

8. Consider a person wearing special frictionless skis sliding down the ramp shown below. If the skier starts from rest, what is her speed when she reaches the bottom of the ramp? Ignore air resistance.



   (a) 47 m/s

   (b) 5.5 m/s

   (c) 24 m/s

   (d) 9.8 m/s

   (e) 6.9 m/s

$F = ma = mg \sin 40 \Rightarrow a = g \sin 40$

$v^2 = v_0^2 + 2ax$

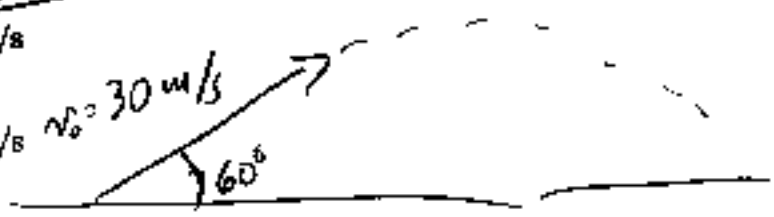
$0 + 2ax$

$v = \sqrt{2ax} = \sqrt{2 \cdot g \sin 40 \cdot \frac{2.4}{\sin 40}}$

$= \sqrt{2(9.8)2.4} = 6.9 \text{ m/s}$

9. An arrow is shot with an initial speed of 30 m/s at an angle of 60° with respect to the horizontal. What is the speed of the arrow when it reaches the point of maximum height on its trajectory? Ignore air resistance.

(a) 30 m/s
(b) 15 m/s
(c) 26 m/s
(d) zero
(e) 52 m/s



at the top $v_y = 0$

$v = v_x = v_{x0} = v_0 \cos 60 = 30 \cdot \frac{1}{2} = 15$ m/s

10. A sky-diver jumps from a plane which is very far above the ground. The sky-diver opens her parachute, and eventually reaches a constant speed of 6.5 m/s. At that time, what is the magnitude of the force due to air drag on the sky-diver and her parachute? Her total mass (including equipment) is 80 kg. Note that you *cannot* ignore air drag in this problem!

(a) 260 N
(b) 780 N
(c) 520 N
(d) zero
(e) 1300 N

$F_{total} = ma$

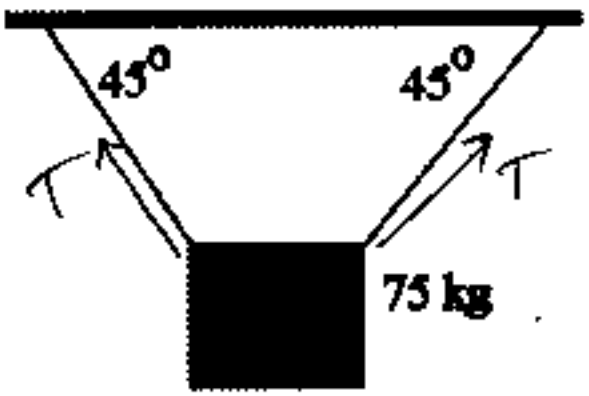
v = constant so $a = 0$

$F_{total} = 0$

$F_{grav} + F_{air\,drag}$

$F_{air\,drag} = -F_{grav} = mg = 80(9.8) = 780$ N

11. Consider a box which is suspended by two cables as shown below. Find the tension in the cable on the left. Assume that the cables are massless.



(a) 740 N
(b) zero
(c) 75 N
(d) 370 N
(e) 520 N

$2 \cdot T \cdot \sin 45 = mg$

$T = \frac{mg}{2 \sin 45} = \frac{75(9.8)}{2 \frac{1}{\sqrt{2}}} = 520N$

12. A ball is thrown straight up into the air with an initial speed of 35 m/s. How long is it in the air? Assume that it starts at ground level, and that air resistance is negligible.

(a) 3.6 s
(b) 0.28 s
(c) 0.14 s
(d) 7.1 s
(e) 9.0 s

$y = y_0 + v_{y0} t - \frac{1}{2} g t^2$

$0 = 0 + v_{y0} t - \frac{1}{2} g t^2$

$t = \frac{2 v_{y0}}{g} = \frac{2(35)}{9.8} = 7.15$

The End