Name: KEY

Student ID #: ____________________

Examination 1 Spring 2008 Physics 211 Professor P.L. Cole

Date Feb. 11, 2008

Test Time: 50 minutes

Write your name on each page. Do the easier problems first. If a problem seems too difficult, skip it, and return to it once you have completed all of the other problems first. There are six pages to this test. You will find a formula sheet on the last page. An extra sheet is provided for scratch.

You must show all work. No credit will be assigned for answers without the appropriate work.

Problem 1	____________	**(30 pts)**
Problem 2	____________	**(30 pts)**
Problem 3	____________	**(30 pts)**
Problem 4	____________	**(15 pts)**
Maximum	____________	**(100 pts)**

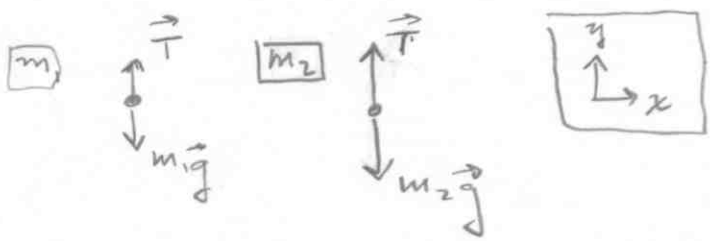
Name: ____________________

Problem 1. **Atwood's Machine.**

A system of two masses, m_1 and m_2, are suspended over a pulley by an inelastic string, as depicted in the figure below. You may assume that both the string and the pulley are massless and that $m_1 > m_2$.

a) Draw free body diagrams for both masses.
b) Which way will m_1 accelerate and which way will m_2 accelerate?
c) Calculate the acceleration of the masses in terms of m_1, m_2, and g.
d) Comment on why this might be a good way to measure g.
e) Give one example of an application of Atwood's Machine in daily life.

a)



b) m_1 will accelerate down $(-\hat{j})$ and m_2 will accelerate up $(+\hat{j})$

c) • $T - m_1 g = -m_1 a \Rightarrow T = m_1 g - m_1 a$ (1)

• $T - m_2 g = +m_2 a \Rightarrow T = m_2 g + m_2 a$ (2)

Equating (1) and (2)

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

$$\boxed{a = \left(\frac{m_1 - m_2}{m_1 + m_2}\right) g}$$

d) If m_1 and m_2 are close in mass, then the acceleration will not be so big. One can measure the time it takes to travel a distance Δy and from $\Delta y = \frac{1}{2} a t^2$ (starting from rest) we have

$$a = \frac{2\Delta y}{t^2} \Rightarrow g = \left(\frac{m_1 + m_2}{m_1 - m_2}\right) \frac{2\Delta y}{t^2}.$$

e) The counter-weighted elevator is one example. Another example is using counterweights to counterbalance each "leaf" of a drawbridge. And yet another example is the funicular, which is a counterbalanced cable train

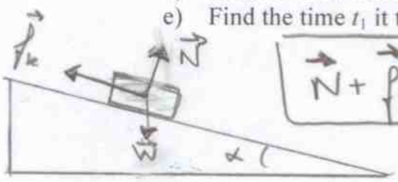
PLC 02/09/08

Name: ____________________

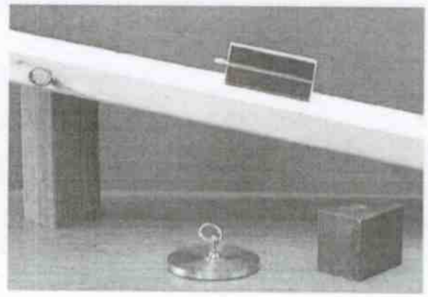
Problem 2. Sliding Block

A block of mass 1.0001 kg is released from rest on the inclined plane as depicted below. The incline makes an angle of 11° with respect to the horizontal. It slides 1.0 m down along the length of the incline, where the coefficient of kinetic friction is 0.1002.

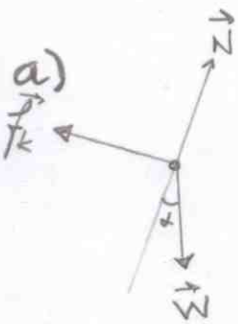
a) Draw the free body diagram for the block as it is traveling down the incline.
b) Draw your *x*-*y* axes. Hint. The *y* direction should be parallel to the normal force.
c) Resolve these forces into components and apply Newton's second law accordingly.
d) What is the acceleration of the block as it slides down the incline?
e) Find the time t_1 it takes to slide down this distance of 1.0 m.



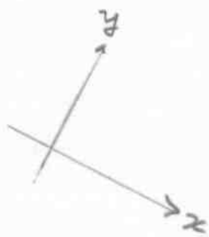
$$\boxed{\vec{N} + \vec{f}_k + \vec{W} = m\vec{a}}$$



a)



b)



c) (1) $\sum F_x$: $W\sin\alpha - f_k = ma$

(2) $\sum F_y$: $N - W\cos\alpha = 0$

d) From (2): $N = W\cos\alpha = mg\cos\alpha$ (3)

From (1) $mg\sin\alpha - \mu_k N = ma$ (4) $\leftarrow f_k = \mu_k N$

Inserting (3) into (4)

$$ma = mg\sin\alpha - \mu_k mg\cos\alpha \Rightarrow \boxed{a = g(\sin\alpha - \mu_k\cos\alpha)}$$

with numbers:

$$a = (9.80\,m/s^2)[\sin 11° - 0.100\cos 11°]$$

$$\boxed{a = 0.91\,m/s^2}$$

e) $$\Delta s = \frac{1}{2}at^2 \Rightarrow \boxed{t = \left[\frac{2\Delta s}{a}\right]^{1/2}}$$

$$t = \left[\frac{2(1.0\,m)}{0.91\,m/s^2}\right]^{1/2}$$

$$\boxed{t = 1.5\,s}$$

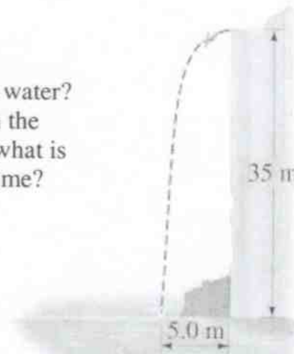
PLC 02/09/08

Name: ______________________

Problem 3. Projectile Motion

The cliff divers of Acapulco push off horizontally from rock platforms about 35 m above the water, but they must clear rocky outcrops at water level that extend out into the water 5.0 m from the base of the cliff directly under their launch point. See in the figure. You may neglect the effects of air friction.

a) How long are these divers in the air?
b) What minimum push-off speed is necessary to clear the rocks?
c) What then are the components of this velocity as the divers enter the water?
d) For example, as a 60.0-kg diver enters the water she plunges beneath the surface and comes to rest in 1.5 s. Assuming constant acceleration, what is the magnitude of the average force that she experiences during this time? And how does this force compare with her weight?

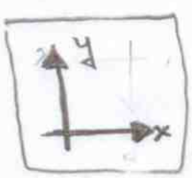


a) $\underbrace{y}_{h} = \cancel{y_0} + \underbrace{\cancel{v_{0y}}}_{0}t - \frac{1}{2}gt^2 \Rightarrow t = \left[\frac{2h}{g}\right]^{1/2}$ $\boxed{+\uparrow}$

$t = \left[\frac{2(35\,m)}{9.8\,m/s^2}\right]^{1/2}$; $\boxed{t = 2.7\,s}$

b) $\Delta x = v_{0x}t \Rightarrow v_{0x} = \frac{\Delta x}{t} = \frac{5.0\,m}{2.7\,s}$ $\boxed{v_{0x} = 1.9\,m/s}$ = speed

c) $\vec{V} = V_{0x}\hat{i} + V_y\hat{j}$; $V_y = V_{y0} - gt = 0 - (9.8\,m/s)(2.7\,s)$



$V_y = -26.\,m/s$

$\vec{V} = \underbrace{(-1.9\,m/s)}_{V_x}\hat{i} + \underbrace{(-26.\,m/s)}_{V_y}\hat{j}$

d) The diver enters the water at a speed of $|\vec{V}| \cong 26.\,m/s$ at an angle of $\alpha = 4.2°$

Assuming constant acceleration: $a = \frac{\Delta V}{\Delta t} = \frac{V_f - V_i}{\Delta t} = \frac{0 - (-26.\,m/s)}{1.5\,s}$

$\underline{a = 17\,m/s^2}$ (in the $+\hat{j}$)

$F = ma = (60.0\,kg)(17.\,m/s^2) \cong \boxed{1000\,N}$

$W = mg = (60.0\,kg)(9.8\,m/s^2) = 590\,N$

$\boxed{F/W = 1.7}$

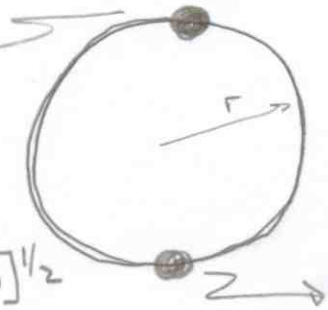
Name: ____________________

Problem 4. Uniform Circular Motion.

A bucket of mass 2.00 kg is whirled in a vertical circle of radius 1.00 m at constant speed.

a) How fast must the bucket move at the top of the circle so that the rope does not go slack?
b) What is the tension in the rope when the bucket is at its lowest point of the vertical circle?
c) How many revolutions per minute (rpm) does this bucket make?

a) $\vec{T} = 0$ (at the top)



$\sum F_{rad}$: $mg = m v^2/r$

$\boxed{V = \sqrt{gr}}$; $V = [(9.80\,m/s^2)(1.00\,m)]^{1/2}$

$\boxed{V = 3.13\,m/s}$

b) $\sum F_{rad}$: $T - W = m v^2/r \rightarrow T = mg + m v^2/r$

$T = m\left(g + \frac{(gr)}{r}\right) = 2mg$

Tension $\Rightarrow T = 2(2.00\,kg)(9.80\,m/s^2)$ $\boxed{T = 39.2\,N}$

c) $V = \frac{2\pi r}{T} \Rightarrow T = \frac{2\pi r}{V} = 2\pi\left(\frac{1.00\,m}{3.13\,m/s}\right) = \underline{2.01\,s}$

period

$T^{-1} = \left(\frac{1\,rev}{2.01\,s}\right)\left(\frac{60\,s}{1\,min}\right) \Rightarrow \boxed{T^{-1} = 30\,rpm}$

It takes 2 seconds to make 1 revolution or 1/2 revolution is one second

PLL 02/09/08