Physics 8A Section 2 Midterm #1

March 6, 2003

Lecture 2

Your name

Solution Set

Discussion session number / GSI name

a) DON'T OPEN THIS EXAM BOOK UNTIL INSTRUCTED TO BEGIN
b) Sit one seat away from anyone else.
c) This exam is 2 hours long and contains 5 problems.
d) Do all your work on the page indicated for each problem.
e) Show all work; don't just write an answer without showing your reasoning.
f) This is a closed book exam; calculators and one 8.5" x 11" sheet of notes is allowed.
g) To simplify the math, you can take the acceleration due to gravity as $g = 10\ m/s^2$.
h) Possibly useful equations include:

$v \equiv dx / dt$
$a \equiv dv / dt$
$x = x_0 + v_0 t + 1/2\ a t^2$
$F = m a = dp / dt$
$p = mv$
$F_c = m v^2 / r$
$W = F x$

$F_s = \mu_s N$
$F_k = \mu_k N$
$K = 1/2\ m v^2$
$U = m g h$
$U = 1/2\ k x^2$
$W = \Delta U + \Delta K + \Delta E_{th} + \Delta E_{in}$

**SCORING - we'll handle this space : )** 1)

**All problems have the same maximum credit.** 2)

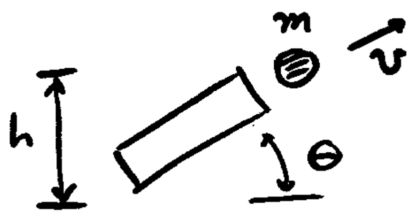
3)

4)

5)

TOTAL

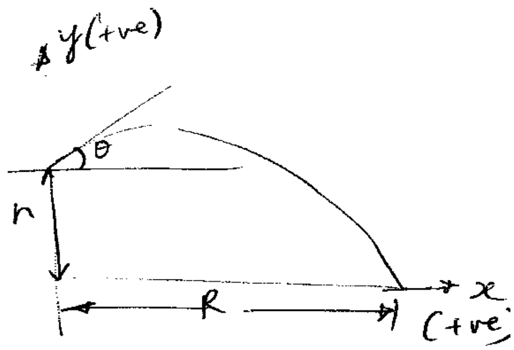
1) A cannon shoots a ball with mass **m = 10 kg** and an initial velocity **v = 10 m/s** at an angle **θ = 30°** upward from the horizontal. The top of the canon barrel is at a height **h = 5 m** above the ground.




a) How long is the ball in the air?

b) How far horizontally from the cannon does the ball land?

c) What is the kinetic energy of the ball as it hits the ground?




(a) $v_{ox} = v\cos\theta = 10\cos 30° = 5\sqrt{3}\ m/sec$

$v_{oy} = v\sin\theta = 10\sin 30° = 5\ m/sec$

y-axis

$-h = v_{oy}t_f - \frac{1}{2}g t_f^2$

$\Rightarrow -\cancel{5} = \cancel{5}t_f - \cancel{5}t_f^2 \quad \therefore \quad t_f^2 - t_f - 1 = 0$

$t_f = \frac{1 \mp \sqrt{1+4}}{2} = 1 \mp \sqrt{5}/2 \qquad t_f = \underline{1.62 sec}$

The ball is in the air for $\underline{1.62\ sec}$.

(b) $R = v_{ox}t_f$

$= 5\sqrt{3} \times 1.62 = 5 \times 1.732 \times 1.62 = 14\ m$

(c) $K.E_f = \frac{1}{2}m V_{fx}^2 + \frac{1}{2}m V_{fy}^2$

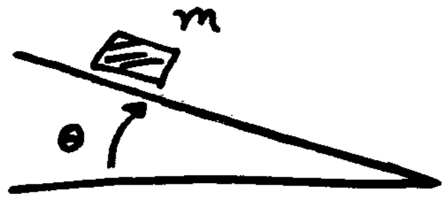
$= \frac{1}{2}m V_{ox}^2 + \frac{1}{2}m(V_{oy} - gt_f)^2$

$= \frac{1}{2}m V_{ox}^2 + \frac{1}{2}m(V_{oy} - gt_f)^2$

$= 5(5\sqrt{3})^2 + 5(5 - 16.2)^2 = 375 + 627.2 = 1002.2 J$

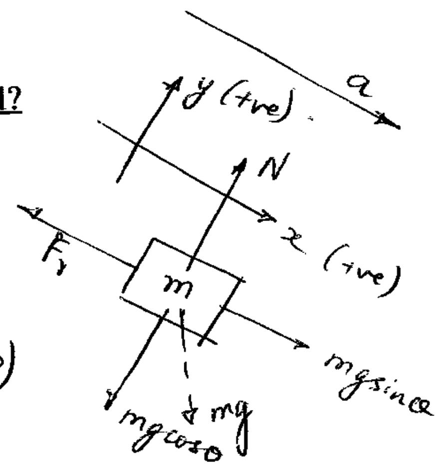
$= \underline{1.0022 KJ}$

2) A mass **m = 10 kg** starts sliding down a hill which is at an angle of **θ = 45°** to the horizontal. The mass starts sliding from a height **h = 10 m**. The coefficient of kinetic friction is **μ = 0.3**




a) What is the acceleration of the mass down the hill?

b) How long does it take the mass to reach the bottom of the hill?




(a) $F_r = \mu N = \mu mg\cos\theta$

Since $N = mg\cos\theta$ $\left(\sum F_y = 0\right)$

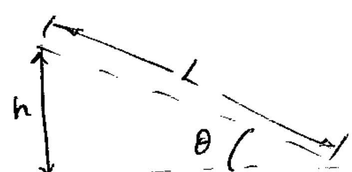
$\therefore$ $\cancel{m}g\sin\theta - \mu\cancel{m}g\cos\theta = \cancel{m}a$

$\therefore$ $a = g(\sin\theta - \mu\cos\theta) = 10(\sin 45° - 0.3\cos 45°)$

$= 10\left(\frac{1}{\sqrt{2}} - \frac{0.3}{\sqrt{2}}\right) = 7/\sqrt{2}$ m/sec²

$=$ 4.95 m/sec²

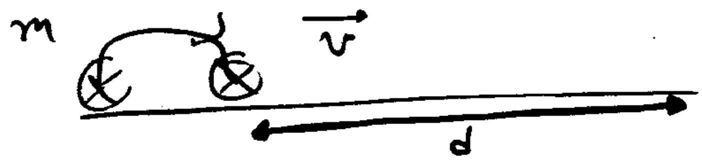
(b) $L = h\,\mathrm{cosec}\,\theta = h\sqrt{2} = 10\sqrt{2}$ m




$L = \frac{1}{2}at^2$

$\therefore$ $t = \sqrt{\frac{2L}{a}} = \sqrt{\frac{2 \times 10\sqrt{2}}{7/\sqrt{2}}} = \sqrt{\frac{40}{7}} = 2.39$ seconds

3) A bicycle with a mass **m = 50 kg** has a velocity **v = 10 m/s**. The bicycle skids to a stop with uniform negative acceleration over a distance **d = 10 m**.




a) What is the frictional force on the bicycle?

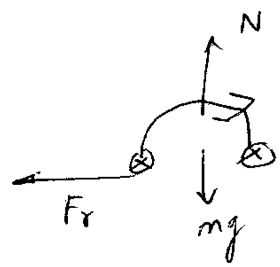
b) What was the coefficient of friction of the road with the tires?

(a) $0 = v + at$ final velocity $= 0$

$$0^2 - v^2 = 2a(d - \cancel{d_0})$$

$\Rightarrow$ $a = \frac{-v^2}{2d} = -\frac{100}{20} = -5\,m/sec^2$

$\therefore$ Deceleration $= \underline{5\,m/sec^2}$.




$F_r = \mu N$

~~(b)~~ Decelerating force $= ma$
$= 50 \times 5 = 250\,N$

This is provided by friction, therefore friction force $= 250N$.

(b) $F_r = \mu N = \mu mg = 250\ N$

$\therefore$ $\mu = \frac{250}{50 \times 10} = 0.5$

4) A mass **m = 10 kg** is placed at the end of a horizontal and compressed spring that has a spring constant **k = 50 N/m**. The spring is then released, releasing its energy to shoot the mass horizontally along a track. The mass enters a vertical loop-de-loop configuration of a track that has a radius **r = 10 m**. The mass just barely makes it around the loop without losing contact and falling.


a) What is the velocity of the mass at the top of the loop?

b) What was the original displacement of the end of the spring from its position of relaxation?

(a) Since the mass barely makes it to the top of the loop, the centripetal force at that point is provided only by gravity as normal reaction is zero.

$$\therefore \quad \cancel{m}g = \cancel{m}v^2/r \qquad v^2/r = g.$$

$$v = \sqrt{gr} = \sqrt{10\times 10} = 10 \text{ m/sec}.$$

(b) The energy at the top most point is obtained from spring energy therefore

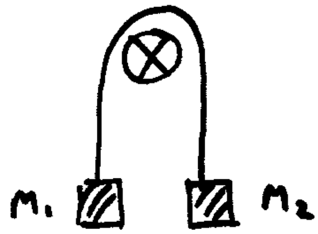
$$\tfrac{1}{2}kx^2 = \tfrac{1}{2}mv^2 + mg(2r)$$

$$= mgr + 2mgr = 3mgr$$

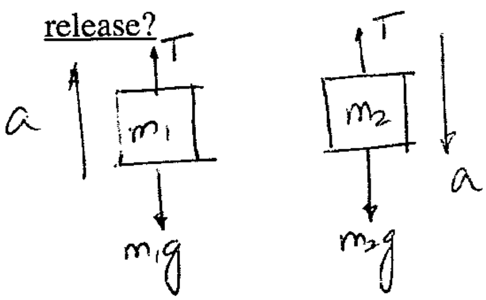
$$x = \sqrt{\frac{6mgr}{k}} = \sqrt{\frac{6\times 10\times 10\times 1\cancel{0}}{5\cancel{0}}} = 10\sqrt{\frac{6}{5}} \text{ m}$$

$$= 10.95 \text{ m}$$

5) Two masses, $\mathbf{m_1 = 20\ kg}$ and $\mathbf{m_2 = 30\ kg}$, hang down at the opposite ends of a rope that has been placed over a massless pulley. Initially the masses are held at the same height. Then they are released.




a) <u>What is the difference between the height of the two masses at a time **t = 2 s** after release?</u>




$m_2 g - T = m_2 a$

$T - m_1 g = m_1 a$

"a" is acceleration magnitude for both masses.

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

$\therefore \quad a = \left(\frac{30-20}{30+20}\right) \times 10 = \underline{\underline{2\ m/sec^2}}$

After 2 sec $m_1$ moves $\frac{1}{2} a t^2 = \frac{1}{2} \times 2 \times (2)^2$
$= 4\ m$ <u>upwards</u>.

After 2 sec $m_2$ moves $\frac{1}{2} a t^2 = \frac{1}{2} \times 2 \times (2)^2$
$= 4\ m$ <u>downwards</u>.

$\therefore$ They are now separated totally by a distance

$4 + 4 = \underline{\underline{8m}}$.