Massachusetts Institute of Technology
Department of Physics

Physics 8.01L

SAMPLE EXAM 1 SOLUTIONS September 26, 2005

Problem 1

a)

$$x = \frac{1}{2}At^2 = \frac{1}{2}A(2)^2 = 2A$$
$$V_x = At = 2A$$

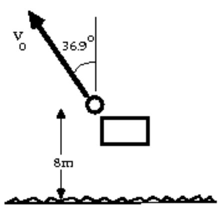
b)

8 seconds to run $100 - 2Am$ at speed $2A$.

$$8(2A) = 100 - 2A \quad 18A = 100 \quad A = \frac{100}{18}$$
$$x = 2A + 2At$$
$$x = 100, \text{ at } t = 8$$
$$100 = 2A + 2A(8)$$
$$A = \frac{100}{18}$$

Problem 2

a)



$$x = v_0 sin(36.9°)t = 0.6v_0t$$
$$v_x = v_0 sin(36.9°) = 0.6v_0$$
$$y = 8 + v_0 cos(36.9°)t = \frac{1}{2}gt^2 = 8 + 0.8v_0t - \frac{1}{2}gt^2$$
$$v_y = v_0 cos(36.9°) - gt = 0.8v_0 - gt$$

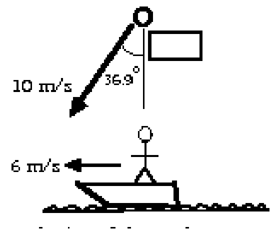
b)

At top, $v_y = 0 \quad 0 = 0.8v_0 - 10 * (2) \quad v_0 = \frac{20}{0.8}$.

$$y = 8 + 0.8(\frac{20}{0.8})(2) - \frac{1}{2}(10)(2)^2 = 8 + 40 - 20$$
$$y = 28m.$$

Problem 3

a)

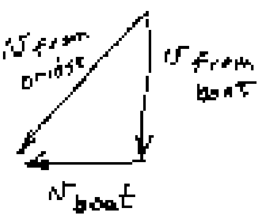


$$v_x = 10sin(36.9°) = 6 \quad m/s$$
$$v_y = -10cos(36.9°) = -8 \quad m/s$$

b)

$$v_x = 6 - 6 = 0m/s$$
$$v_y = -8 - 0 = -8m/s$$

c)



Problem 4

a)

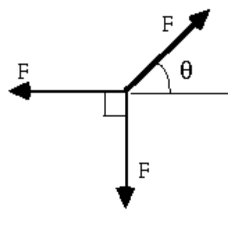
$$v_x = B - 2Ct \qquad a_x = -2C$$
$$v_y = E + FGsin(Gt) \qquad a_y = FG^2cos(Gt)$$
$$v_z = FGcos(Gt) \qquad a_z = -FG^2sin(Gt)$$

b)

$$|a| = \sqrt{4C^2 + F^2G^4}$$

Magnitude constant, direction changes.

Problem 5



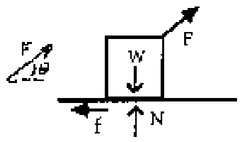
$\sum F_x = Fcos(\theta) - F$ Can't be zero unless $\theta = 0$.

$\sum F_y = Fsin(\theta) - F$ Can't be zero unless $\theta = 90°$.

$\Rightarrow$ Can't both be zero. Answer is (2).

Problem 6

a)



○ $F = f$ and $N = W$

○ $F = f$ and $N > W$

$\Rightarrow$ ○ $F > f$ and $N < W$

○ $F > f$ and $N = W$

○ None of the above choices is correct.

$$f = Fcos(\theta) < F$$
$$N + Fsin(\theta) = W \quad N < W$$

Problem 7

a)

$$v_x = a + 3bt^2 = 2 + \frac{3}{2}t^2$$
$$v_y = ABcos(Bt) = \pi cos(\frac{\pi}{2}t)$$

b)

$$a_x = 6bt = 3t$$
$$a_y = -AB^2 sin(Bt) = -\frac{\pi^2}{2} sin(\frac{\pi}{2}t)$$

c)

	x	y	v_x	v_y	a_x	a_y
0	0	0	2	π	0	0
1	$2\frac{1}{2}$	2	$3\frac{1}{2}$	0	3	$\frac{-\pi^2}{2} \approx 5$

Problem 8

$$x_1 = 40t - \frac{1}{2}(1)t^2 \quad v_1 = 40 - t$$
$$x_2 = 50 + 30t \quad v_2 = 30$$

Method 1:

$$v_1 = v_2 \quad @ \quad t = 10$$
$$x_1 = 400 - 50 = 350$$
$$x_2 = 50 + 300 = 350$$

$\Rightarrow$ Don't pass $\Rightarrow$ No ticket!

Method 2:

$$x_1 = x_2 \Rightarrow \quad 40t - \frac{1}{2}t^2 = 50 + 30t$$
$$\frac{1}{2}t^2 - 10t + 30 = 0$$
$$t = \frac{10 \pm \sqrt{100 - 4(\frac{1}{2})(50)}}{1} = 10$$

Only happens once $\Rightarrow$ You don't pass.

Problem 9

a) Boost phase: $y = \frac{1}{2}BT_1^2 \quad v_y = BT_1$.

Gravity phase: $y = \frac{1}{2}BT_1^2 + BT_1 t - \frac{1}{2}gt^2$
$v_y = 0 \quad @ \quad 0 = (BT_1)^2 - 2g(y - \frac{1}{2}BT_1^2) \quad$ or $t = \frac{BT_1}{g}$.

$H = \frac{B^2T_1^2}{2g} + \frac{1}{2}BT_1^2$

b) $T_{max} = T_1 + t$

where $0 = \frac{1}{2}BT_1^2 + BT_1 t - \frac{1}{2}gt^2$

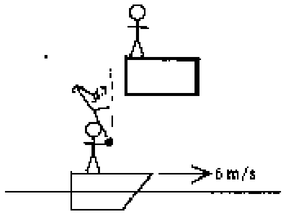
If $B = g \Rightarrow t^2 - 2T_1 t - T_1^2 = 0$

$t = \frac{2T_1 + \sqrt{4T_1^2 + 4T_1^2}}{2}$

$t = T_1 + \sqrt{2}T_1$

$T_{max} = 2T_1 + \sqrt{2}T_1 = T_1(2 + \sqrt{2})$.

Problem 10



Want: $v_{boat,x} + v_{ball,x} = 0$

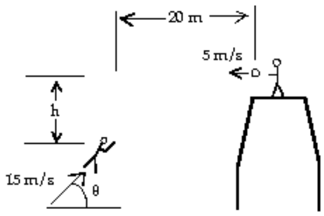
$\Rightarrow v_{ball,x}$ must be < 0

$6 - v_0 sin(36.9°) = 0$

$6 - v_0(0.6) = 0$

$v_0 = 10m/s.$

Problem 11



a)

Acrobat	Basketball
$x = 0 + 15cos(\theta)t + 0$	$x = 20 - 5t$
$x = 11.5t$	$y = h - \frac{1}{2}gt^2 = h - 4.9t^2$
$y = 0 + 15sin(\theta)t - \frac{1}{2}gt^2$	
$y = 9.6t - 4.9t^2$	

b) $x_1 = x_2$ at $11.5t = 20 - 5t \Rightarrow t = 1.21s.$

c) Acrobat: $y = 4.44m.$

Basketball: $y = h - 4.9t^2 = h - 7.20 = 4.44m.$

$h = 11.6m.$

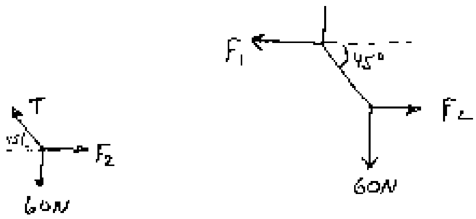
d)

Acrobat	Basketball	Relative
$v_x = 11.5m/s$	$v_x = -5m/s$	$v_x = -5(-11.5) = -16.5m/s$
$v_y = -2.26m/s$	$v_y = -11.9m/s$	$v_y = -11.9 - (-2.26) = -9.6m/s$
		Mag $= 19.1m/s$

Problem 12

Young & Freedman 5.11 on page 194.

a)

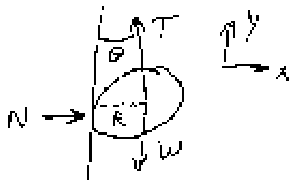


$Tsin(45°) = 60N \quad T = 85N$

b) $Tcos(45°) = F_2 \Rightarrow F_2 = 60N$

c) Looking at the diagonal string $F_1 = F_2$, so $F_1 = 60N$.

Young & Freedman 5.12 on page 194.



$\sum F_y = Tcos(\theta) - w = 0$

$T = w/cos(\theta)$

$\sum F_x = N - Tsin(\theta) = 0$

$N = Tsin(\theta) = wtan(\theta)$

You can find θ from $sin(\theta) = \frac{R}{l+R}$, where l is the length of the string:

$\theta = 4.2° \quad T = 2.7N \quad N = 0.2N$