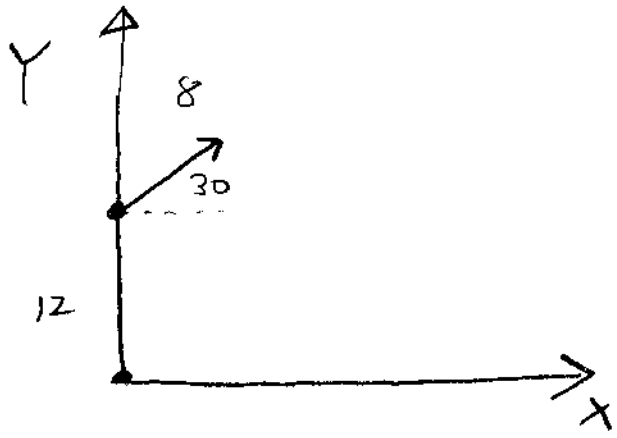
MIDTERM 1

Physics 9A, Fall 2009 **NAME:** KEY

General Instructions: This examination is closed book. Only a calculator is allowed. Please show all your work and box your answers. Credit will only be given for *complete* solutions. Answers must have correct units. There are five problems on four pages. Note that not all the problems are worth the same number of points. The acceleration due to gravity is $g = 9.8$ m/s^2.

1. **(25 points)** A rock is thrown from the roof of a building with a velocity $v_0 = 8$ m/s at an angle $\theta = 30°$ from the horizontal. The building has height $h = 12$ m. You can ignore air resistance. How far from the base of the building does the rock strike the ground?



$X = X_0 + v_{x0} t + \frac{1}{2} a_x t^2$

$X = 0 + (8 \cos 30) t + 0$

$Y = Y_0 + v_{Y0} t + \frac{1}{2} a_y t^2$

$Y = 12 + (8 \sin 30) t - 4.9 t^2$

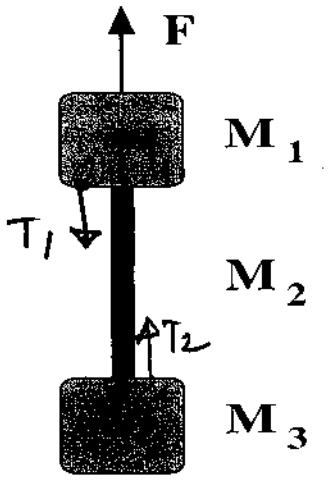
Hits ground when $Y = 0$

$0 = 12 + 4t - 4.9 t^2 \qquad 4.9 t^2 - 4t - 12 = 0$

$t = \frac{4 \pm \sqrt{16 + 4(12)(4.9)}}{2(4.9)} = 2.02$

range $R = (8 \cos 30)(2.02) = 14.03$ m

2. **(25 points)** Two blocks of mass $M_1 = 5$ kg and $M_3 = 8$ kg are connected with a heavy rope of mass $M_2 = 2$ kg. An upward force of 240 N is applied as shown. (a) Draw a figure showing all the forces on the bottom block. For each force, indicate which body exerts that force. (b) What is the acceleration of the system? (c) What is the tension at the top of the heavy rope? (d) What is the tension at the bottom of the heavy rope?



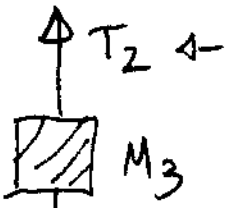
$240 - 5(9.8) - T_1 = 5a$ ← top block

$T_1 - T_2 - 2(9.8) = 2a$ ← rope

$T_2 - 8(9.8) = 8a$ ← bottom block

$240 - 15(9.8) = 15a$

(a)



T_2 ← force of rope on bottom block

W ← weight of bottom block (force exerted by earth)

(b) $a = 6.2\ m/s^2$

(c) $T_1 = 240 - 5(9.8) - 5a$

$= 240 - 5(9.8 + 6.2)$

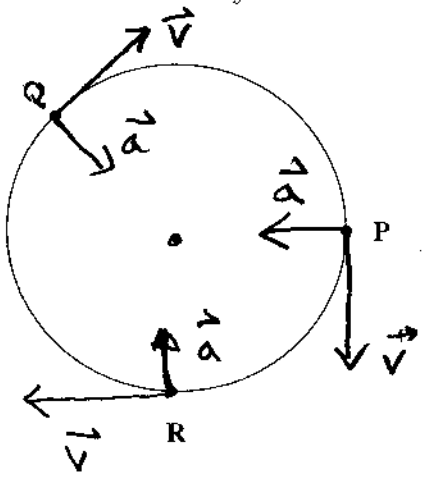
$= 160$

(d) $T_2 = 8(9.8 + 6.2)$

$= 128\ N$

check $160 - 128 - 19.6 = 2(6.2)$ ✓

3. **(15 points)** A ball takes 0.25 seconds to go around a circle of radius 3 m. It moves with constant speed and goes around the circle clockwise. On the figure, indicate the directions of the velocity and acceleration vectors at the points P, Q and R. What are the magnitudes of the velocity and acceleration vectors at point P? Are the magnitudes different at Q?



$$\text{speed} = \frac{2\pi r}{T} = \frac{2\pi(3)}{.25} = 75.4 \text{ m/s}$$

↑ length of $\vec{v}$

$|\vec{r}|$

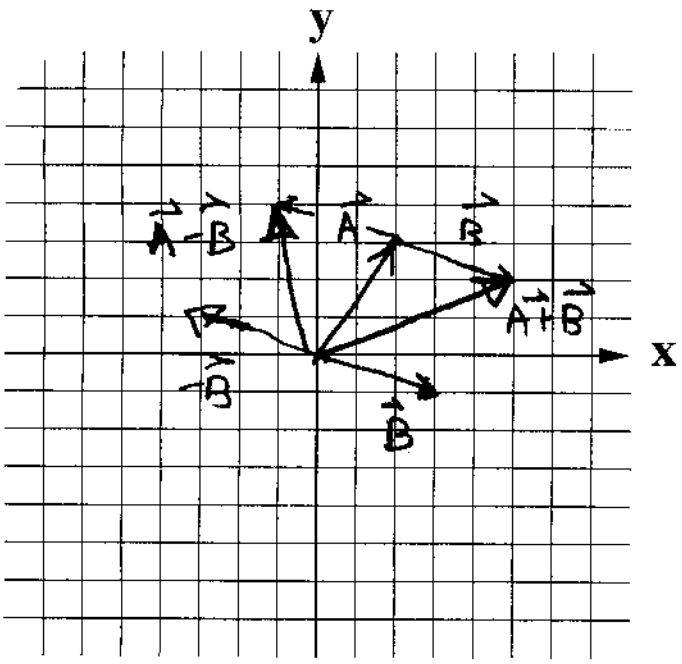
Speed is same at all points

magnitude of acceleration $|\vec{a}|$ is also same at all points

$$|\vec{a}| = |\vec{v}|^2/r = (75.4)^2/3 = 1895 \text{ m/s}^2$$

huge!

4. **(15 points)** Draw the two vectors $\vec{A} = 2\hat{i} + 3\hat{j}$ and $\vec{B} = 3\hat{i} - \hat{j}$. Draw their sum $\vec{A} + \vec{B}$ and their difference $\vec{A} - \vec{B}$. What is $\vec{A} - \vec{B}$ in terms of $\hat{i}$ and $\hat{j}$?



$$\vec{A} - \vec{B} = -\hat{\imath} + 4\hat{\jmath}$$

5. **(20 points)** A police car chases a speeder. The speeder travels at a constant speed of 32 m/s. The maximum speed of the police car is 48 m/s. The police car starts from rest and accelerates at constant acceleration at 4 m/s^2 until it reaches a speed of 48 m/s. It then moves with constant speed. (a) When does the police car catch the speeder if it starts just as the speeder passes? (b) How far has each car traveled? (c) Draw a single plot of position versus time which contains $x(t)$ for both the police car and the speeder. Choose your origin as the point when the speeder passes the policeman. Label your graph by showing the time t when the police car stops accelerating and the positions of both vehicles at that time, and the time and positions when the police car catches the speeder.

S = Speeder

P = police car

$X_S = 32t$

$X_P = \frac{1}{2}\, 4\, t^2$ until $v = 4t = 48$ (12 seconds)

After 12 seconds $X_S = 32(12) = 384$

$x_P = \frac{1}{2}\, 4(12)^2 = 288$

police car is 96 m behind and going 16 m/s faster (48 − 32) will catch in 6 more seconds

speeder will have traveled

$X_S = 32 \cdot (12 + 6)$

$= 576$ m

same for policeman