KEY

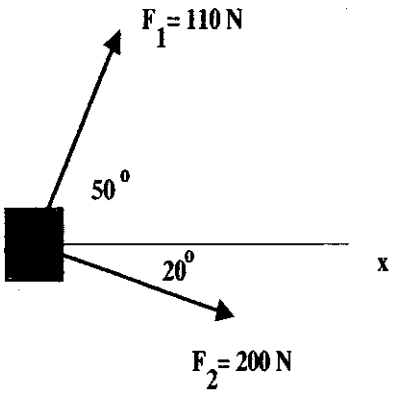
MIDTERM 1

Physics 9A Section C **NAME:**

April 18, 2007 **ID #:**

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 four 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.

25 points] 1. Two adults and a child want to push a wheeled cart in the direction marked x in the Figure. The two adults push with forces $\vec{F}_1$ and $\vec{F}_2$ as shown. (a) Find the magnitude and direction of the *smallest* force the child should exert. You can ignore the effects of friction. (b) If the child exerts the minimum force found in part (a), the cart accelerates at 3.0 m/s^2 in the $+x$ direction. What is the mass of the cart?



a) $F_x^{TOT} = 110\cos 50 + 200\cos 20 + F_x = ma_x$

$F_y^{TOT} = 110\sin 50 - 200\sin 20 + F_y = ma_y$

$a_y = 0$ So $F_y = -15.86$ N

If Force is smallest, $F_x = 0$

b) $F_x = 0$ $F_x^{TOT} = 258.6 = m\,3$

$m = 86.21$ kg

[30 points] **2.** A police car chases a speeder. The speeder travels at a constant speed of 30 m/s. The maximum speed of the police car is 50 m/s. The police car starts from rest and accelerates at constant acceleration at 5 m/s^2 until it reaches a speed of 50 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.

While accelerating, police car travels

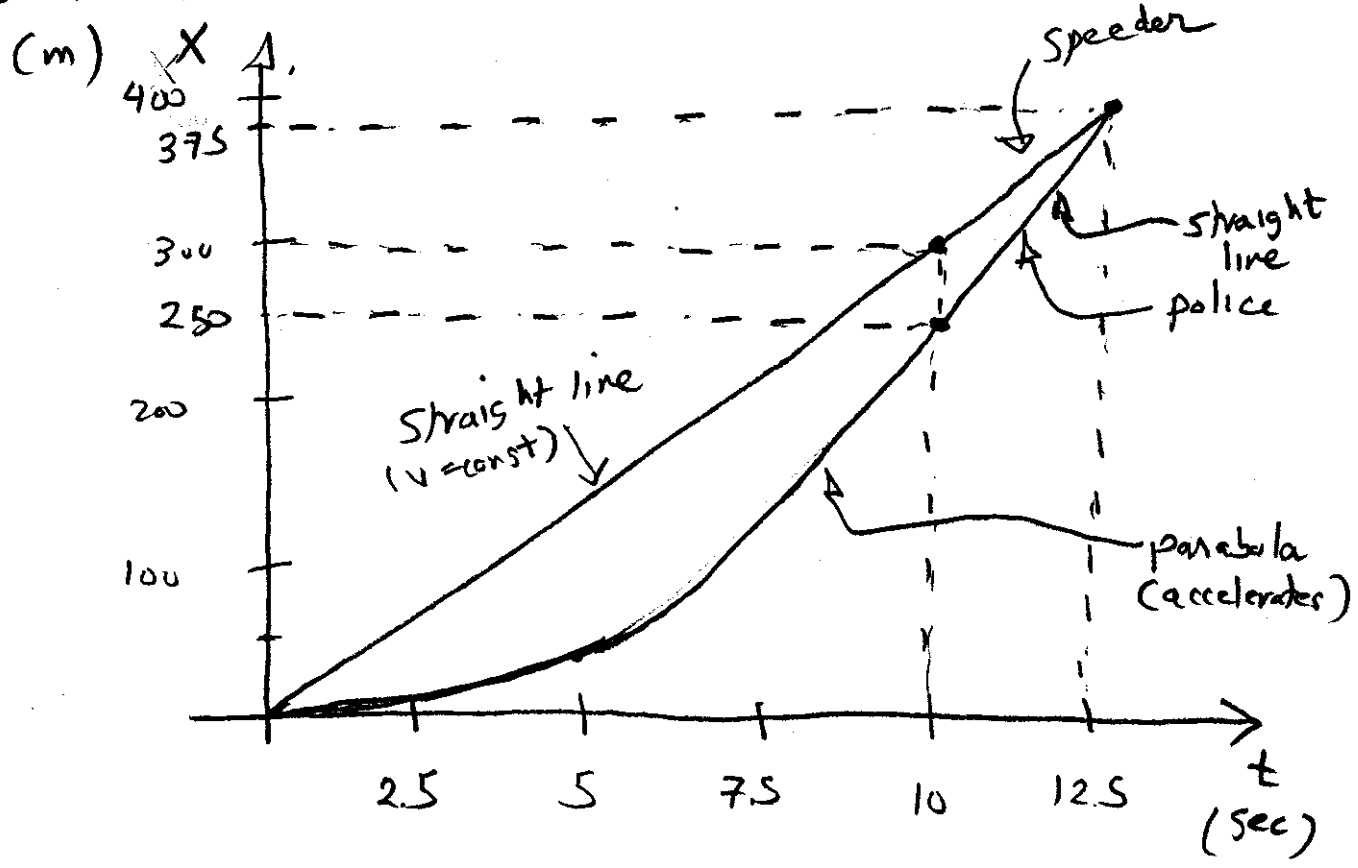
$x_p = \frac{1}{2} 5 (10)^2$ since it takes $t = 10$ sec to get to 50 m/s with $a = 5$ m/s^2

$= 250$ m.

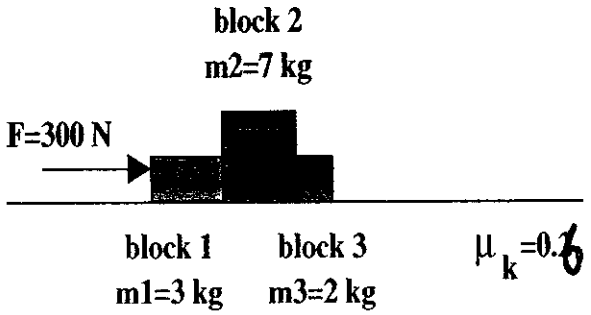
The speeder travels

$x_s = 30 \cdot 10 = 300$ m in this time.

The police car is then moving 20 m/s faster than the speeder and will take 2.5 seconds to close the 50 m gap. So the police car catches the speeder at $t = 12.5$ s when $x_s = x_p = 375$ m.



25 points] 3. Three blocks are arranged in a horizontal row as shown. The masses of the blocks are $m_1 = 3$ kg, $m_2 = 7$ kg, and $m_3 = 2$ kg. A horizontal force $F = 300$ N is applied. The coefficient of kinetic friction is $\mu_k = 0.6$ for all three blocks. What is the acceleration of the blocks? What is the force (magnitude and direction) that block 1 exerts on block 2? What is the force (magnitude and direction) that block 3 exerts on block 2?



Consider all 3 blocks as single unit

$$300 - \underbrace{(3+2+7)(9.8)}_{N}(0.6) = (3+2+7)a$$

$$a = 19.12 \text{ m/s}^2$$

Consider blocks 2 and 3

$$F_{1 \text{ on } 2} - (2+7)9.8(0.6) = (2+7)a$$

$$F_{1 \text{ on } 2} = 225 \text{ N} \quad \text{to the right}$$

Consider Just block 2

$$225 + F_{3 \text{ on } 2} - 7(9.8)(.6) = 7a$$

$$F_{3 \text{ on } 2} = -50 \text{ N} \quad \overset{50 \text{ N}}{(\text{ie to the left})}$$

Check

$$F_{2 \text{ on } 3} - 2(9.8)(.6) \overset{?}{=} 2a$$

$$F_{2 \text{ on } 3} = 50 \text{ N} = -F_{3 \text{ on } 2}$$ ☑

20 points] 4. The earth has a radius of 6380 km and turns around its axis once every 24 hrs. (a) What is the radial acceleration of an object at the earth's equator? Give your answer in m/s^2 and as a fraction of g. (b) If a_{rad} were greater than g, objects would fly off the earth's surface and into space. What would the period of the earth's rotation have to be for this to occur?

a) $a = \frac{v^2}{r}$

$v = \frac{2\pi r}{T} = \frac{2\pi\ 6380\ 1000\ m}{86400\ sec} = 464\ m/s$

$a = (464)^2 / 6380 \cdot 1000 = .0337\ m/s^2 = .00344g$

b) $a = 9.8 = v^2/r$

$v = \sqrt{9.8\,(6380 \cdot 1000)} = 7907\ m/s$

$T = \frac{2\pi r}{v} = \frac{2\pi\ 6380\ 1000}{7907} = 5070\ sec$

$(= 1.41\ hrs$

$= .0587\ day\ )$