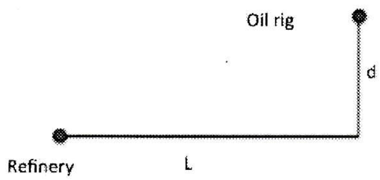
PART II (52%) In your exam booklet provide full solutions to 4 out of 5 problems below.

ON THE COVER OF THE EXAM BOOKLET INDICATE CLEARLY WHICH PROBLEMS YOU WANT TO BE MARKED

1 John, who is member of certain NGO, has missed the meeting of his protest group at the refinery, and now needs to get to the oil rig in the shortest time to join the demonstrators who are trying to disrupt the work of the petroleum company. John needs to run along the shore and then enter the water at point of his choosing.
John can run at 8km/h but can paddle at only 3 km/h using his small inflated dinghy. L=10km, d=5km



a) How far from the Refinery should John enter the water to get to the oil rig in the shortest time (7P)

b) What is the minimum time it will take to get to the oil rig? (3P)

c)By algebraic manipulation of the first two kinematic equations for one-dimensional motion:

$$1)v_f = v_i + at \qquad 2)x_f = x_i + v_i t + \tfrac{1}{2}at^2$$

Obtain the other two kinematic equations:

$$3)v_f^2 - v_i^2 = 2a\Delta x \qquad 4)x_f = x_i + \tfrac{1}{2}(v_i + v_f)t \qquad \text{(3P)}$$

2 Speedy Sue, driving at 30.0 m/s, enters a one-lane tunnel. She then observes a slow-moving van 155 m ahead traveling at 5.00 m/s. Sue applies her brakes but can accelerate only at $-2.00\ m/s^2$ because the road is wet. Will there be a collision? If yes, determine how far into the tunnel and at what time the collision occurs. If no, determine the distance of closest approach between Sue's car and the van. (13P)

3 One strategy in a snowball fight is to throw a snowball at a high angle over level ground. While your opponent is watching the first one, a second snowball is thrown at a low angle timed to arrive before, or at the same time as the first one. Assume both snowballs are thrown with a speed of 25.0 m/s. The first one is thrown at an angle of 70.0° with respect to the horizontal.
(a) At what angle should the second snowball be thrown to arrive at the same point as the first? (6P)
(b) How much later should the second snowball be thrown (after the first) to arrive at the same time? (4P)
(c) Using the first principles demonstrate that the range (R) of a projectile launched at initial velocity v_0 at the angle θ above the horizontal plane is given by:

$$R = \frac{v_0^2 \sin 2\theta}{g} \qquad \text{(3P)}$$

4 A race car starts from rest on a circular track of radius R. The car increases its speed at a constant rate a_t as it goes once around the track.

a) Find the angle that the total acceleration of the car makes with the radius connecting the center of the track and the car- at the moment the car completes the circle. (7P)
b) Find the speed at that position (3P)
c) Find the time it took to make the full circle. (3P)

5 Draw the proper free-body diagrams indicating all of the forces, and write down relevant Newton's Equations for x and y component of the forces for the following cases:

a) single mass M resting on the flat surface (5P)
b) single mass M resting on the inclined, flat surface (the angle of inclination is θ and the coefficient of static friction μ_{stat} (5P)).
c) Mass M resting on the floor of the elevator, attached by a taut vertical string to the ceiling of the elevator. The elevator is accelerating up with a. (3P)

$a = -2 \text{ m/s}$

$v = 30 \text{ m/s}$

2.) Sue

~~Find time it takes for Sue to break in 155m~~

x_i x_f

Van

x_i $v = 5 \text{ m/s}$ x_f

~~$x_f - x_i = vt + \frac{1}{2}at^2$~~

~~$155 - 0 = 30t + \frac{1}{2}(-2)t^2$~~

~~$155 = 30t - t^2$~~

~~$0 = -155 + 30t - t^2$~~

~~Quadratic formula = 27 secs~~

~~It takes Sue 27 secs to brake to stop 155m away.~~

Find time they collide (solve t)

Van	Sue
$x_f - x_i = vt$	$x_f - x_i = vt + \frac{1}{2}at^2$
$-155 + x_f = 5t$	$x_f = 30t - t^2$

What dis will Sue be in 25 secs?

Assumption is correct!

$x_f = vt + \frac{1}{2}at^2$

$x_f = 30(25) + \frac{1}{2}(-2)(25)^2$

$x_f = 750 - 625$

$x_f = 125\text{m}$

$155 + 5t = 30t - t^2$

$= 25t - t^2$

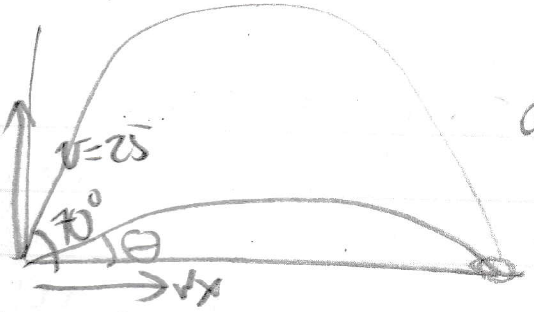
$= t(25 - t)$

0 25 secs

when they meet

∴ Yes they will collide at 25 seconds and it will be 125m into tunnel.

3.)



a)

$v = 25. m/s$

$v_{1x} = v_{2x}$

Find time

$x_f = (v_0 \cos\theta) t$

$41m = (25 \cos 70) t$

$t = 4.8 secs$

$R = \frac{v_0^2 \sin 2\theta}{g}$

$R = \frac{(25)^2 \sin 2 \cdot 70°}{9.8}$

$R = 40.99 m$

13/13

$y = (\tan\theta) x - \frac{g}{2v_i^2 \cos^2\theta} x^2$

$0 = (\tan\theta) 41 - \frac{9.81 (41)^2}{2(25)^2} (1 + \tan^2\theta)$

$= 41 \tan\theta - 13.18 + -13.18 \tan^2\theta$

$= -13.18 + 41 \tan\theta - 13.18 \tan^2\theta$

$\frac{-b \pm \sqrt{b^2 - 4ac}}{2a} = \frac{-(41) \pm \sqrt{(41)^2 - 4(-13.18)(-13.18)}}{2(-13.18)}$

$= \frac{-41 \pm \sqrt{1,681 - 694.9}}{2(-13.18)}$

$= \frac{-41 \pm \sqrt{986.1}}{-26.38}$

$\frac{-41 + \sqrt{986.1}}{-26.38}$ OR $\frac{-41 - \sqrt{986.1}}{-26.36}$

$\tan\theta = 0.36$ 6 $\tan\theta = 2.75$

$\theta = 19.8°$ $= 69.9$

b.) $x_f = (v_0 \cos\theta)t$

$41m = (25\cos(19.8))t$

$t_2 = 1.74$

$t_1 = 4.8$ secs

~~3.5~~

∴ should be thrown after $(4.8 - 1.74)$

$\boxed{= 3.06 \text{ secs}}$

4

c.) $y = (\tan\theta)x - \frac{g}{2v_0^2\cos^2\theta}x^2$

$y = (\tan\theta)x - \frac{g}{2v_0^2}x^2 \cdot \frac{1}{\cos^2\theta}$

$y = \left(\frac{\sin\theta}{\cos\theta}\right)x - \frac{gx^2}{2v_0^2} \cdot \frac{\sin^2\theta + \cos^2\theta}{\cos^2\theta}$

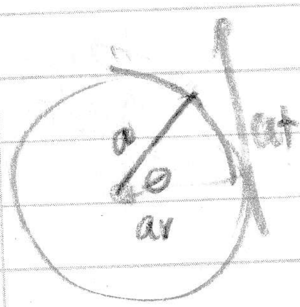
$y = \frac{\sin\theta}{\cos\theta}x - \frac{gx^2}{2v_0^2} \circ \tan^2\theta$

$= \frac{2v_0^2 \sin\cos\theta}{g}$

3

$R = \frac{v_0^2 \sin 2\theta}{g}$

4.)



a.) $v = \frac{2\pi r}{T}$ (1) and (2)

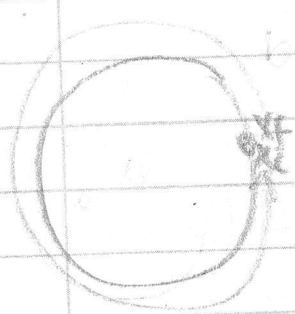
(1) $r = \frac{vT}{2\pi}$

(2) $|a_r| = \frac{v^2}{r}$

$|a_r| = \frac{v^2}{\frac{vT}{2\pi}} = \frac{v^2 2\pi}{vT} = \frac{v2\pi}{T}$

$\cos\theta = \frac{a_r}{a}$

$\theta = \cos^{-1}\left(\frac{v2\pi a}{T}\right)$



b.) $|a_r| = \frac{v^2}{r}$

$a\cos\theta = \frac{v^2}{r}$

circumference $= 2\pi r$

$v = \sqrt{a\cos\theta r}$

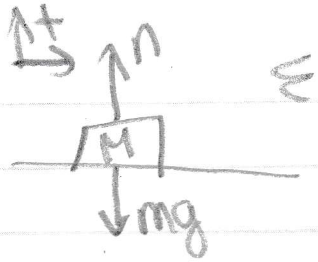
c.) x_i —— x_f

time $= T$

$v = \frac{2\pi r}{T}$

$T = \frac{2\pi r}{v}$

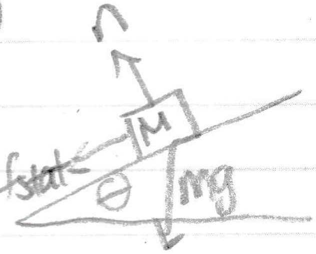
5.) a)

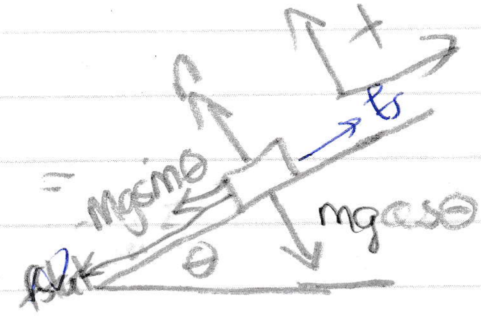


$\sum F_x = 0$ $\sum F_y = n - mg$

5

b.)





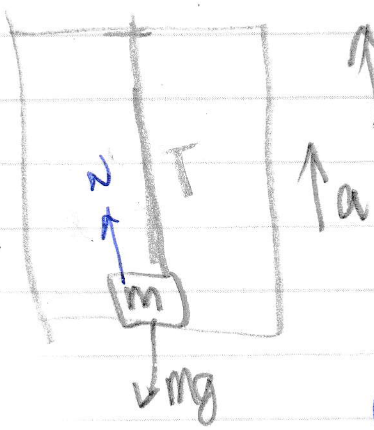
$\sum F_x = m\vec{a}$

$m\vec{a} = \cancel{f_{stat}} - mg\sin\theta$

$\sum F_y = 0$

$0 = n - mg\cos\theta$

c.)



$\sum F_x = 0$

$0 = 0$

$\sum F_y = m\vec{a}$

$m\vec{a} = T - mg$

2