ARANMORE CATHOLIC COLLEGE

PHYSICS 3A3B - 2010

ASSIGNMENT #2

NAME: ______________________________ **MARK:** /50

1. Taylah visits a space station which is in a circular orbit at a distance of one earth radius above the earth's surface.

   a) What will be the acceleration due to gravity on Taylah in the station? [4 marks]

$G = 6.67 \times 10^{-11}\ N m^2 kg^{-2}$

$M_E = 5.98 \times 10^{24}\ kg$

(1) $r = 2 r_E = 1.274 \times 10^{7}\ m$

$$g = \frac{GM}{r^2} \quad (1)$$

$$g = \frac{6.67 \times 10^{-11} \times 5.98 \times 10^{24}}{(1.274 \times 10^{7})^2} \quad (1)$$

$$g = 2.46\ N kg^{-1}. \quad (1)$$

   b) Find the speed of the station and Taylah in their circular orbit. [3 marks]

$$a_c = g = \frac{V^2}{r} \quad (1)$$

$$V = \sqrt{g r} = \sqrt{2.46 \times 1.27 \times 10^{7}} \quad (1)$$

$$= 5595\ m s^{-1} \quad (1)$$

$$= 5.60\ km s^{-1}.$$

   c) How long will it take Taylah to make one complete revolution? [2 marks]

$$T = \frac{2 \pi r}{V} \quad (1)$$

$$= \frac{2 \times \pi \times 1.27 \times 10^{7}}{5595}$$

$$= 14261\ s \quad (238\ min) \quad (1)$$

$$= 3.96\ h.$$

2. Modern values for the mass of the Earth and other planets have been determined by observing the motion of artificial satellites that have been launched in recent years.

a) Derive an expression for the mass of a central body, for example the Earth, in terms of the orbital radius (R) and orbital period (T) of an artificial satellite.

[3 marks]

(1) $F_g = F_c$; & $V = \frac{2\pi r}{T}$

(1) $\frac{GMm}{r^2} = \frac{mv^2}{r}$; so $M = \frac{4\pi^2 r^3}{GT^2}$. (1)

$M = \frac{v^2 r}{G}$

b) One of Mars' moons, Phobos, revolves around Mars with an orbital radius of 9.35×10^3 km and with a period of 7 hours and 35 minutes. Use your expression from part (a) above to determine the mass of Mars.

[4 marks]

$r = 9350$ km

(1) $= 9.35 \times 10^6$ m

$T = 7$h 35 min

(1) $= 27300$ s

$M_{MARS} = \frac{4\pi^2 (9.35 \times 10^6)^3}{6.67 \times 10^{-11} \times (27300)^2}$ (1)

$= 6.49 \times 10^{23}$ kg. (1)

c) What is the value for the acceleration due to gravity, 'g', on the surface of Mars, given that Mars has a radius of 3430 km?

[4 marks]

$r = 3.43 \times 10^6$ m

(1)

$g = \frac{G M_M}{r^2}$ (1)

$= \frac{6.67 \times 10^{-11} \times 6.49 \times 10^{23}}{(3.43 \times 10^6)^2}$ (1)

$= 3.68$ N kg^{-1}. (1)

d) What is the orbital speed of Phobos (in ms^{-1})?

[3 marks]

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

$= \frac{2\pi \times 9.35 \times 10^6}{27300} = 2152$ ms^{-1}. (1)

$= 2.15$ km s^{-1}. (1)

e) Is Phobos accelerating? Explain.

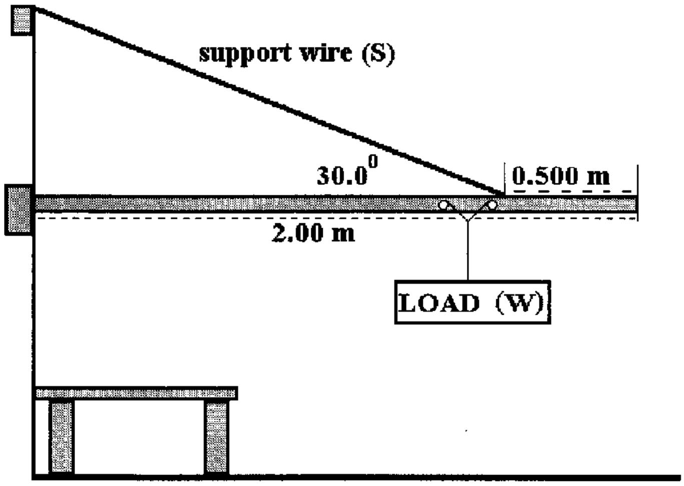
[2 marks]

(1) YES, - CIRCULAR MOTION

- CONSTANT SPEED, BUT DIRECTION CHANGES

(1) - ACCELERATION TOWARDS CENTRE OF MARS.

3. Ceara has a wall crane illustrated below. It is designed to lift motors from cars and transfer them to a workbench using rollers. This allows Ceara to shift the load from one end of the beam to the other, as shown in the diagram.



a) If the uniform beam has a mass of 40.0 kg and the load (W) is 2.00×10^2 kg, find the force in the support wire (S) when the load is at the outer end. [5 marks]

PIVOT POINT AT WALL: (1)

$$\sum \tau_{AC} = \sum \tau_{C} \quad (1)$$

$$(1) \quad 1.5 \times T \sin 30^\circ = 1 \times 40 \times 9.8 + 2 \times 200 \times 9.8 \quad (1)$$

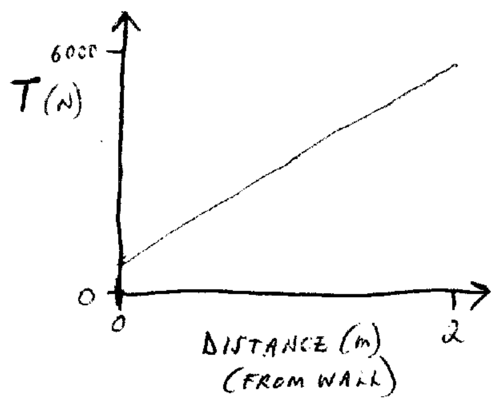
$$0.75T = 392 + 3920$$

$$T = \frac{4312}{0.75}$$

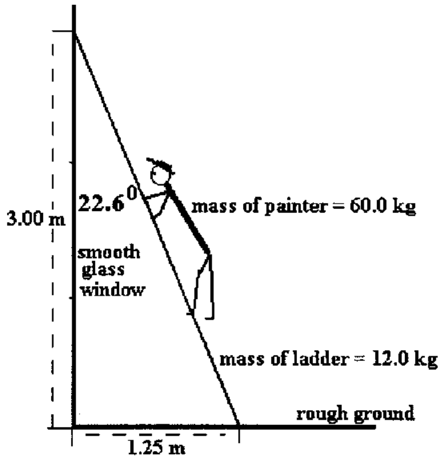
$$= 5750 \text{ N.} \quad (1)$$

b) Sketch a graph to show how the force in the wire varies as Ceara moves the load in towards the wall. [3 marks]

1 - LABELLING
1 - LINE
1 - NOT INTERSECTING AT ZERO TENSION.



4. Tito, a painter, rests a 12.0 kg wooden extension ladder of length 3.25 m against a smooth window surface at an angle of 22.6^0 to the glass.



a) What force is the ladder exerting on the glass? (Since the glass is smooth, the force will be perpendicular to the window.) [5 marks]

TAKE PIVOT POINT AT GROUND: (1)

$$\sum \tau_C = \sum \tau_{AC}$$

(1) $$3 \times F_{GLASS} = \frac{1.25}{2} \times F_{LADDER}$$ (1)

$$F_{GLASS} = \frac{0.625 \times 12 \times 9.8}{3}$$ (1)

$$= 24.5 \text{ N.}$$ (1)

b) The glass will break if subjected to a force greater than 150 N at the point where the ladder is resting on it. How far up the ladder can Tito climb before disaster strikes? [5 marks]

SAME AS (a) BUT WITH TITO: (1)

(1) $$3 \times 150 = 0.625 \times 117.6 + x\, 60 \times 9.8$$ (1)

$$450 = 73.5 + 588x$$

$$x = \frac{376.5}{588} = 0.64 \text{ m}$$ (1)

THIS IS THE HORIZONTAL DISTANCE OF TITO:

$$\sin 22.6 = \frac{0.64}{L}$$

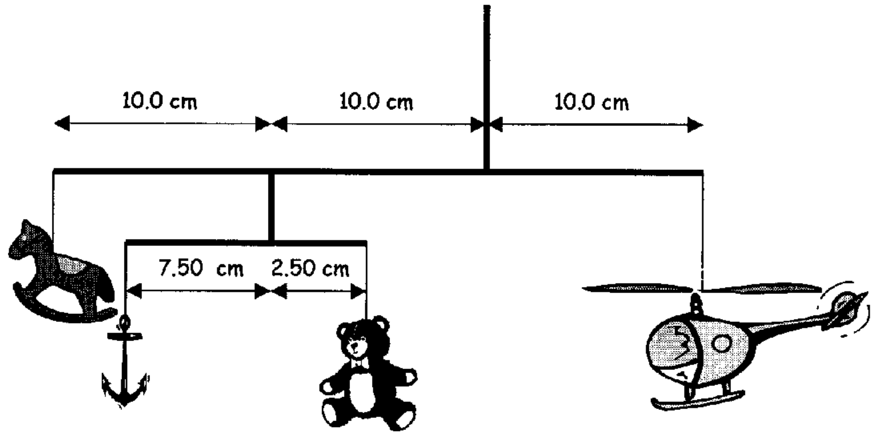
$$L = \frac{0.64}{\sin 22.6}$$

$$L = 1.67 \text{ m.}$$ (1)

TITO CAN ASCEND THE LADDER SO THAT HIS CENTRE OF MASS IS 1.67 m ALONG THE LADDER.

5. Tom's mobile hangs in static equilibrium above his bed, as shown in the diagram below. The mass of the horse is 160.0 g and the mass of the anchor is 60.0 g.

[7 marks]



a) What is the mass of Tom's hanging teddy bear?

$m_{ANCHOR} = 60.0\,g$

$r_{ANCHOR} = 7.50\,cm$

$m_{TEDDY} = ?$

$r_{TEDDY} = 2.50\,cm$

$m_A g r_A = m_T g r_T$ (1)

$m_T = \frac{60.0 \times 7.50}{2.50}$ (1)

$m_T = 180.0\,g.$ (1)

N.B. CONVERSIONS TO kg, m, N not REQUIRED PROVIDED THEY ARE CONSISTENT.

b) What is the mass of Tom's toy helicopter?

$m_{HORSE} = 160.0\,g$

$r_{HORSE} = 20.0\,cm$

$m_{T+A} = 240.0\,g$

$r_{T+A} = 10.0\,cm$

$m_{HELICOPTER} = ?$

$r_{HELICOPTER} = 10.0\,cm$

(1) (1)

$m_{HELI}\, g\, r_{HELI} = m_{HORSE}\, g\, r_{HORSE} + m_{T+A}\, g\, r_{T+A}$

$m_{HELI} = \frac{160 \times 20 + 240 \times 10}{10}$ (1)

$m_{HELI} = 560.0\,g.$ (1)