THE COPPERBELT UNIVERSITY

SCHOOL OF MATHEMATICS AND NATURAL SCIENCES

DEPARTMENT OF PHYSICS

PH 110 TEST 2

Write your names and computer number on the front page of your answer booklet.

DURATION: TWO (2) HOURS

ANSWER ALL QUESTIONS

QUESTION 1

(a) A 25-kg box sits on an inclined plane which is 30° with respect to horizontal. A force of 500 N, [illegible] the box and the incline. [7]

(b) Two blocks connected by a light rope are being dragged by a horizontal force F. Suppose that F=50 N, m_1=10 kg, m_2=20 kg and the coefficient of kinetic friction between each block and the surface is 0.1. Do the following:

(i) Draw a free-body diagram for each block. [4]

(ii) Determine the tension T and the acceleration of the system. [9]

QUESTION 2

a) A wheel that is turning at 10 rev/min speeds up until its speed is 20 rev/min. The change takes 10 s. Find (a) its angular acceleration in rad/s^2, and (b) the number of degrees through which it turned in this time.

b) Mr Katongo, a civil engineer by profession wishes to construct a road round a curve. At what angle should the road be banked in order that the vehicle can go round a curve of radius 50*m* at a constant speed of 30 *km/h*. [4]

c) A body of mass 5 kg is attached to a string 2 m long and moves in a horizontal circle of radius 50cm, as shown in Fig.2.1.

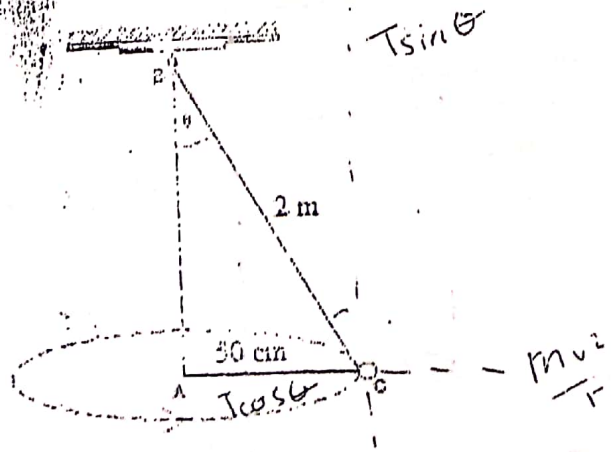

Fig.2.1

i) The tension T in the string. [3]
ii) The angular speed of the bob. [4]
iii) The rotational frequency of the bob [3]

QUESTION 3

a) The system in figure 3 is in equilibrium with the strings in the centre exactly horizontal.

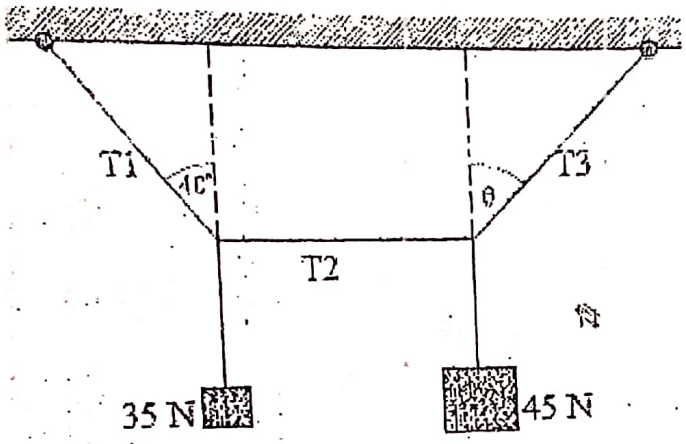

Figure 3

Find [2]
i) Tension T1 [2]
ii) Tension T2 [3]
iii) Angle θ that T3 makes with the vertical. [3]
iv) Tension T3

b) A 8 m uniform ladder of weight 210N stands against a wall at an angle of 50° above the horizontal. There is no friction between the ladder and the wall but the coefficient of static friction between the ladder and the floor is 0.55. An electrician weighing 500N slowly climbs the ladder to fix a light bulb. What is the maximum distance he can climb, measured up the ladder from its base, before the ladder will fall? Take g to be 9.81m/s^2. [10]

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100%

NAME : DEBORA CHIKAMBA

SIN : 15007266

TASK : PH 1110 TEST TWO

PROGRAM : NON. QUOTA

LECTURER : MR. SIMFUKWE

GROUP : D

DATE : 22nd DECEMBER, 2015

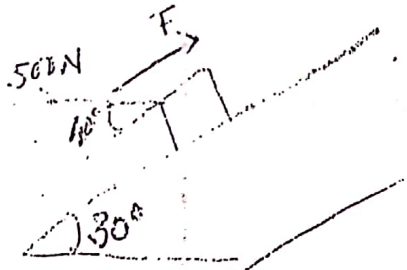
Q1 ____ 20

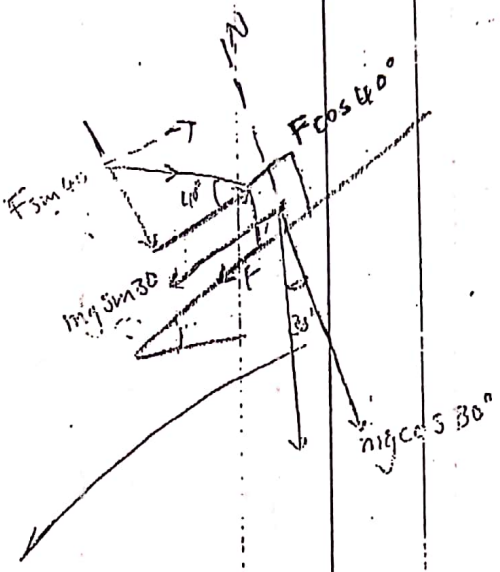
Q2 ____ 20 / 20

Q3 ____ 20 / 20

60 / 60

Question one.





acceleration = 0.75 m/s²

mass = 25 kg

$\Sigma F_{iy} = 0$

$N - F\sin 40 - mg\cos 30 = 0$

$N - 500\sin 40 - 25 \times 9.81 \cos 30 = 0$

$N - 321.4 - 212.4 = 0$

$N = 533.8\,N$

$\Sigma F_{ix} = ma$

$F\cos 40° - mg\sin 30° - f = ma$

$500\cos 40° - 25 \times 9.81 \sin 30 - f = 25 \times 0.75$

$383 - 122.6 - f = 18.75$

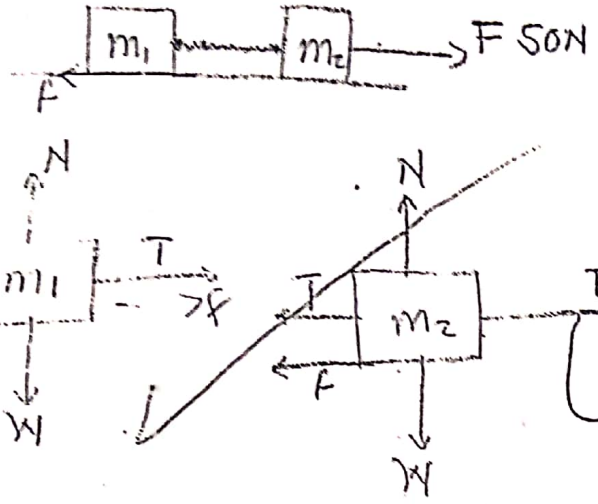
$f = 241.65$

$\therefore f = \mu_k N$

$\frac{241.65}{533.8} = \frac{\mu_k 533.8}{533.8}$

$\mu_k = 0.45$

$F_k = \mu_k N$



$m_1 = 10kg$; $m_2 = 20kg$, $\mu_K = 0.1$, $F = 50N$

mass 1

$\Sigma F_x = ma$

$T - f = ma$

$T - f = 10a$ --(i)

$\Sigma F_y = 0$

$N - W = 0$

$N = W = mg$

$N = 98.1N$

$f = \mu_K N$

$f = 0.1 \times 98.1$

$f = 9.81N$

$T - 9.81 = 10a$

$T - 10a = 9.81$ --(i)

∴ Solving the two equations

$T - 10a = 9.81$

$T + 20a = 30.38$

$-30a = -20.57$

mass 2

$\Sigma F_x = ma$

$F - T - f = 20a$

$50 - T - f = 20a$ --(iv)

$\Sigma F_y = 0$

$N - W = 0$

$N = W = mg$

$N = 196.2$

$f = \mu_K N$

$f = 0.1 \times 196.2$

$f = 19.62N$

$50 - T - 19.62 = 20a$

$30.38 - T = 20a$

$T + 20a = 30.38$ --(ii)

$$\frac{-30a}{-30} = \frac{-20 \cdot 57}{-30}$$

$$a = 0 \cdot 686 \text{ m/s}^2$$

$\therefore T + 20a = 30 \cdot 38$

$T + 20(0 \cdot 686) = 30 \cdot 38$

$T + 13 \cdot 72 = 30 \cdot 38$

$T = 30 \cdot 38 - 13 \cdot 72$

$T = 16 \cdot 66 \text{ N}$ or $16 \cdot 7 \text{ N}$

acceleration $0 \cdot 686 \text{ m/s}^2$

Tension $16 \cdot 66 \text{ N}$

Question two

10 rev/min

$\omega_i = \frac{10 \text{ rev}}{\text{min}} \left(\frac{2\pi}{1 \text{ rev}}\right)\left(\frac{1 \text{ min}}{60 \text{ s}}\right)$

$\omega_i = 1.05 \text{ rad/sec}$

20 rev/min

$\omega_f = \frac{20 \text{ rev}}{\text{min}} \left(\frac{2\pi}{1 \text{ rev}}\right)\left(\frac{1 \text{ min}}{60 \text{ s}}\right)$

$\omega_f = 2.09 \text{ rad/sec}$

(i) $\omega_f = \omega_i + \alpha t$

$2.09 = 1.05 + 10\alpha$

$\frac{2.09 - 1.05}{10} = \frac{10\alpha}{10}$

$\alpha = 0.104 \text{ rad/sec}^2$

(ii) $\theta = \omega_i t + \frac{1}{2}\alpha t^2$

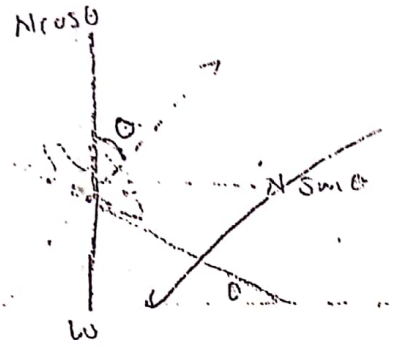
$\theta = 1.05 \times 10 + \frac{1}{2} \times 0.104 \times 100$

$\theta = 15.7 \text{ rad}$

$15.7 \text{ rad} \left(\frac{360^\circ}{2\pi}\right)$

$= 899.5^\circ$

6



Radius 50m

$\Sigma F_x = N \sin\theta = \frac{mv^2}{r}$

$= \frac{mg \sin\theta}{\cos\theta} = \frac{mv^2}{r}$

$= \frac{rmg \tan\theta}{m} = \frac{mv^2}{m}$

$= v^2 = rg \tan\theta$

$= (8.33)^2 = 50 \times 9.81 \tan\theta$

$= \frac{69.39}{490.5} = \frac{490.5 \tan\theta}{490.5}$

$\tan\theta = 0.141$

$\theta = \tan^{-1} 0.141$

$\theta = 8.03^\circ$ or 8°

$30 \frac{km}{h} \left(\frac{1000m}{1km}\right)\left(\frac{1}{3600s}\right)$

$= 8.33 m/s$

$\Sigma F_y = 0$

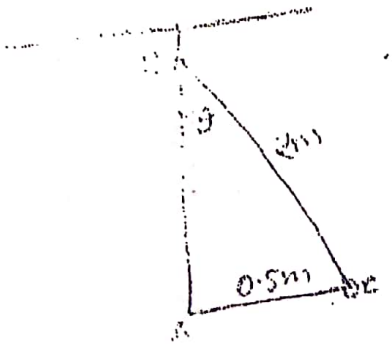
$N \cos\theta = mg$

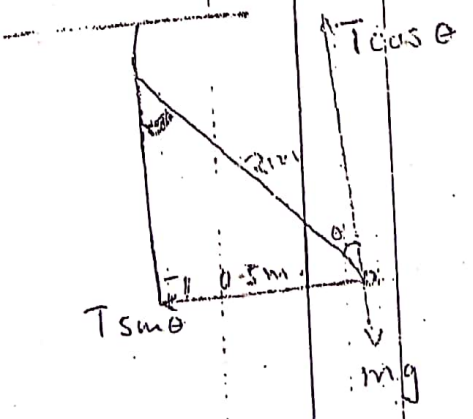
$\frac{\cos\theta}{\cos\theta} \quad \cos\theta$

$N = \frac{mg}{\cos\theta}$

4

c





$m = 5kg$

$r = 0.5m$

Length = 2m long

$\sin\theta = \frac{0.5}{2m}$

$\sin\theta = 0.25$

$\theta = \sin^{-1} 0.25$

$\theta = 14.5°$

$\sum f_y = 0$

$T\cos\theta - mg = 0$

$T\cos 14.5 = 5 \times 9.81$

$\frac{T\cos 14.5}{\cos 14.5} = \frac{49.05}{\cos 14.5}$

$T = 50.74$ B

(ii) $T\sin\theta = mw^2 r$

$50.7 \sin 14.5 = 5 \times 0.5 w^2$

$\frac{12.69}{2.5} = \frac{2.5w^2}{2.5}$

$\sqrt{w^2} = \sqrt{5.076}$ 4

$w = 2.25 \text{ rad/sec}$

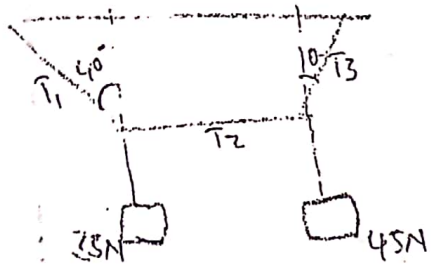
(iii) $w = 2\pi f$ B

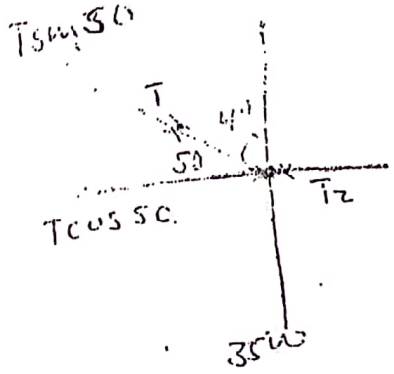
$\frac{2.25}{2\pi} = \frac{2\pi f}{2\pi}$

$f = 0.358 \text{ Hz}$ or 0.057 rev/sec

(25)

Question 3





$\Sigma F_y = 0$

$T \sin 50 - W = 0$

$T \sin 50 = 35$

$\frac{T \sin 50}{\sin 50} = \frac{35}{\sin 50}$

$T_1 = 45.7N$

(ii) $\Sigma F_x = 0$

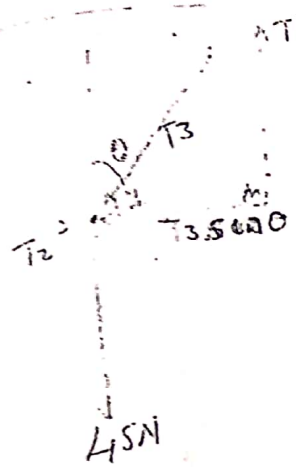
$T \cos 50 - T_2 = 0$

$T \cos 50 = T_2$

$45.7 \cos 50 = T_2$

$T_2 = 29.4N$

(iii)



$\sum Fx = 0$

$T_2 - T_3 \sin\theta = 0$

$T_2 = T_3 \sin\theta$

$29.41 = T_3 \sin\theta$ --- (i)

$\sum Fy = 0$

$T_3 \cos\theta - 45 = 0$ --- (ii)

$\frac{T_3 \cos\theta}{\cos\theta} = \frac{45}{\cos\theta}$

$T_3 = \frac{45}{\cos\theta}$

Substituting in eqn (i)

$29.41 = \frac{45}{\cos\theta} \times \sin\theta$

$\frac{29.41}{45} = \frac{45 \tan\theta}{45}$

$\tan\theta = 0.65$

$\theta = \tan^{-1} 0.65$

$\theta = 33^\circ$

T_3 makes 33° with the vertical

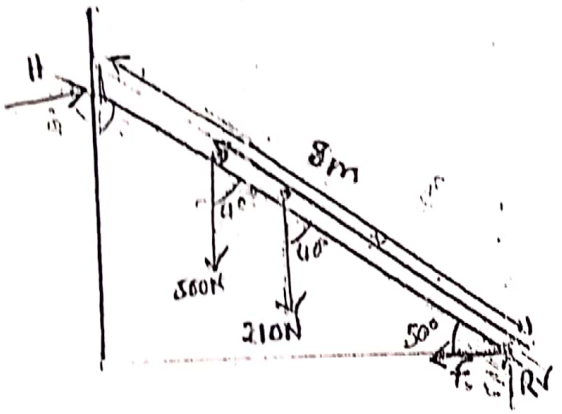
$T_3 = \frac{45}{\cos 0}$

$T_3 = \frac{45}{\cos 33}$

$T_3 = 53.7N$

$T_3 = 53.7N$

10



$\Sigma F_x = 0$

$H - F = 0$

$H = F \quad -- (i)$

$\Sigma F_y = 0$

$R_V - 500N - 210N = 0$

$R_V = 710N$

$\Sigma CCT = H\,8\sin 50°$

$= 6.13H$

$\Sigma CCT = (500 \times \sin 40) + (210 \times 4\sin 40)$

$= 321.4x + 539.9$

Writing are we using Sin here

$R_V = N$

$N = 710N$

$\therefore f = \mu_s N$

$f = 0.55 \times 710$

$f = 390.5N$

Since $H = f$

$H = 390.5N$

$H = 390.5N$

Applying second condition

$$\Sigma CCE - \Sigma CC = 0$$

$$\Sigma CCE = \Sigma CC$$

$$321.4x + 539.9 = 6.13H$$

$$321.4x + 539.9 = 6.13(390.5)$$

$$321.4x + 539.9 = 2393.8$$

$$321.4x = 2393.8 - 539.9$$

$$\frac{321.4x}{321.4} = \frac{1853.9}{321.4}$$

$$x = 5.77m \text{ or } 6m$$

$\therefore$ the maximum distance he can climb measured from its base is 5.77m or 6m

10