BANDA PAUL
GROUP B

COPPERBELT UNIVERSITY

PHYSICS DEPARTMENT

PH 110 TEST 2 (SEPTEMBER 2019)

TIME ALLOWED: **90** MINUTES MAX MARKS: **50**

ATTEMPT **ALL** QUESTIONS. ALL QUESTIONS CARRY EQUAL MARKS

Wherever necessary use:

$$g = 9.8\,m/s^2$$

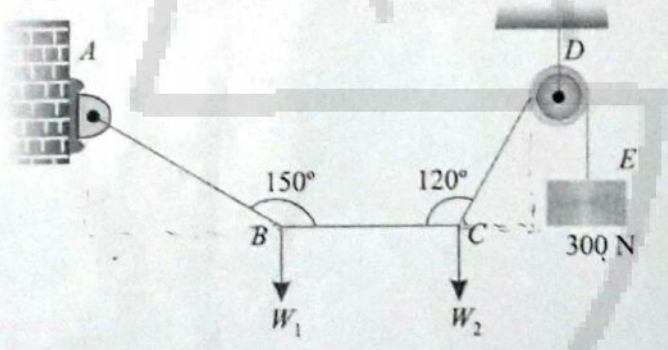
QUESTION ONE

(a) State two conditions necessary for the body to be in static equilibrium. **[3Marks]**

(c) You have a job digging holes for posts to support signs for Fountain Restaurant. Explain why the higher above the ground a sign is mounted, the further the posts should extend into the ground.

[2 Marks]

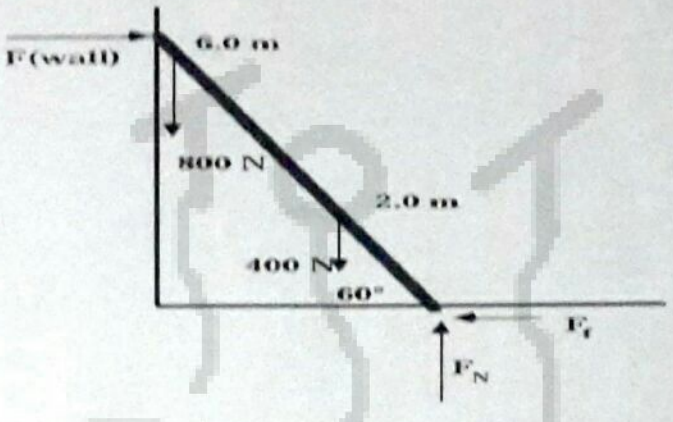
(c) A light string ABCDE whose extremity A is fixed, has weights W_1 and W_2 attached to it at B and C. It passes round a small smooth pulley at D carrying a weight of 300 N at the free end E as shown in the Figure below.



If in the equilibrium position, BC is horizontal and AB and CD make 150° and 120° respectively with BC, Find the tensions in the portion AB, BC and CD of the string, and the magnitudes of W_1 and W_2. **[10 Marks]**

(d) A man who weighs 800 N climbs to the top of a 6 meter ladder that is leaning against a smooth (i.e., **frictionless**) wall at an angle of 60° with the horizontal as sketched in the Figure below. The **non-uniform** ladder weighs 400 N and its center of gravity is 2 meters from the foot of the ladder. What must be the minimum coefficient of static friction between the ground and the foot of the ladder if it is not to slip? **[10 Marks]**

$\tau = rF\cos\theta$



QUESTION TWO

(a) (i) What is an oblique collision? **[2 Marks]**

(ii) State the law of conservation of linear momentum **[2 Marks]**

(iii) Define the coefficient of restitution for a head-on collision between two bodies. **[2 Marks]**

(b) A moving sphere has a head-on elastic collision with an initially stationary sphere. After collision the kinetic energies of the two spheres are equal.

(i) Show that the mass ratio of the two spheres is 0.1716. **[10 Marks]**

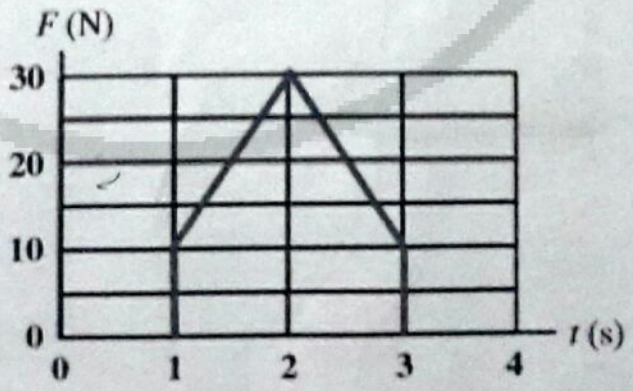
(ii) Which of the two spheres is the more massive? **[2 Marks]**

(c) The force-time graph for a ball struck by a bat is approximated as shown in Figure below. From this graph, find

(i) the impulse delivered by the ball, **[3Marks]**

(ii) the average force exerted on the ball, and **[3Marks]**

(iii) the maximum force exerted on the ball. **[1 Mark]**



&&&&&&&&&&&&&&&&&&&&&&&&**END OF TEST**&&&&&&&&&&&&&&&&&&&&

GLASSY

PH110 TEST 2
09/2019

Q1. (a) The net force acting on the body must be zero

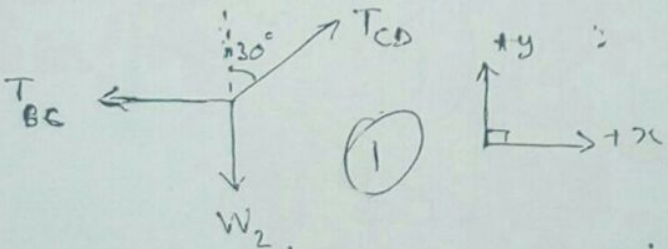
$$\Sigma F_x = \Sigma F_y = \Sigma F_z = 0 \quad (1\frac{1}{2})$$

The net torque acting on the body must be equal to zero

$$\Sigma \tau = 0 \quad (1\frac{1}{2})$$

(b) Since the torque is a product of a force and the lever arm, the higher above the ground the sign is mounted the greater the lever arm and hence the greater the torque.

(c) FBD for node C



(1)

The 1st condition for equilibrium gives

$$\Sigma F_x = 0$$

$$T_{CD}\sin 30^\circ - T_{BC} = 0$$

$$T_{BC} = T_{CD}\sin 30^\circ \quad (1)$$

$$\Sigma F_y = 0$$

$$T_{CD}\cos 30^\circ - W_2 = 0$$

$$W_2 = T_{CD}\cos 30^\circ \quad (1)$$

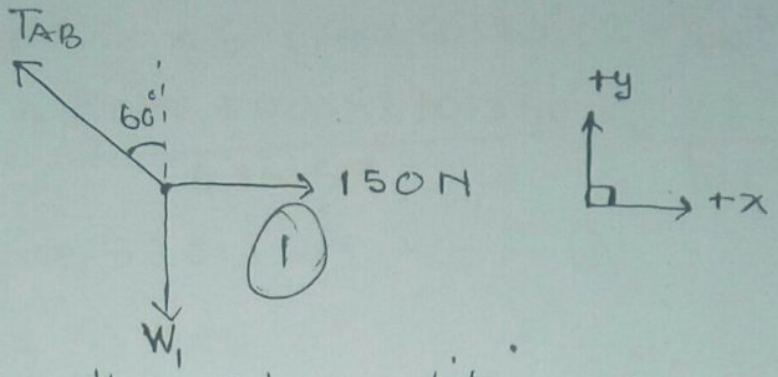
since the pulley is frictionless

$$T_{CD} = 300\,N$$

$$\Rightarrow T_{BC} = (300\,N)\sin 30^\circ = 150\,N \quad (1\frac{1}{2})$$

$$W_2 = 300\cos 30^\circ = 259.8\,N \simeq 260\,N \quad (1\frac{1}{2})$$

FBD for the node at B



From the 1st condition for equilibrium

$\Sigma F_x = 0$

$150 - T_{AB} \sin 60^\circ = 0$

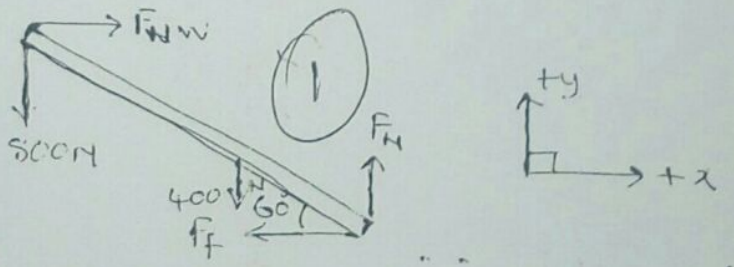
$T_{AB} = \frac{150}{\sin 60^\circ} = 173.2\,N$ // (1½)

$\Sigma F_y = 0$

$T_{AB} \cos 60^\circ - W_1 = 0$

$\Rightarrow W_1 = T_{AB} \cos 60^\circ = 86.6\,N$ //

(d) FBD for ladder



Applying the 1st condition for equilibrium gives

$\Sigma F_y = 0$

$F_N - 800 - 400 = 0$

$\Rightarrow F_N = 1200\,N$ - - - ① (2)

$\Sigma F_x = 0$

$F_{NW} - F_f = 0$

$\Rightarrow F_f = F_{NW}$ - - - ② (2)

Applying the 2nd condition for equilibrium with the axis at the bottom of the ladder gives

$$\Sigma \tau = 0$$

$$800\cos 60^\circ \times 6 + 400\cos 60^\circ \times 2 - F_{NW}\sin 60^\circ \times 6 = 0$$

$$\Rightarrow F_{NW} = \frac{(800\times 6 + 400\times 2)\cos 60^\circ}{6\sin 60^\circ} = \frac{2800}{5.196} \quad (3)$$

$$= 538.56\,N \quad \cdots \quad (3)$$

$$\therefore F_f = 538.86$$

$$\Rightarrow F_f = \mu F_N$$

$$\therefore \mu = f_f / F_N = \frac{538.86\,N}{1200\,N} = 0.449$$

$$= 0.45 // \quad (2)$$

Q2.

(a)

(b) (i) Conservation of momentum, ~~gives~~ with m_1 the mass of sphere initially in motion and m_2 mass of sphere initially at rest, gives

$$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$$

$$m_1u_1 + 0 = m_1v_1 + m_2v_2$$

$$m_1u_1 = m_1v_1 + m_2v_2 \quad \cdots \quad (1) \quad (2)$$

Conservation of KE gives

$$\frac{1}{2}m_1u_1^2 + \frac{1}{2}m_2u_2^2 = \frac{1}{2}m_1v_1^2 + \frac{1}{2}m_2v_2^2$$

$$m_1u_1^2 + 0 = m_1v_1^2 + m_2v_2^2$$

$$m_1u_1^2 = m_1v_1^2 + m_2v_2^2 \quad \cdots \quad (2) \quad (2)$$

Equality of KE gives

$$\frac{1}{2}m_1v_1^2 = \frac{1}{2}m_2v_2^2$$

$$m_1v_1^2 = m_2v_2^2 \quad \cdots \quad (3) \quad (1)$$

substituting Eqn (3) in Eqn (2) gives

$$m_1u_1^2 = m_1v_1^2 + m_1v_1^2 = 2m_1v_1^2$$

$$\Rightarrow u_1 = \sqrt{2}\,v_1 \quad \cdots \quad (4) \quad (1)$$

Substituting Eqn (4) into Eqn (1) we get

$$m_1(\sqrt{2})V_1 = m_1V_1 + m_2V_2$$

$$\Rightarrow V_2 = \frac{m_1}{m_2}(\sqrt{2}-1)V_1 \quad \cdots (5) \quad (1)$$

Substituting Eqn (5) into Eqn (3) gives

$$m_1V_1^2 = m_2V_2^2 = m_2\left[\frac{m_1}{m_2}(\sqrt{2}-1)V_1\right]^2$$

$$m_1V_1^2 = m_2 \times \frac{m_1^2}{m_2^2}(\sqrt{2}-1)^2V_1^2 \quad (2)$$

$$m_1V_1^2 = \frac{m_1}{m_2}(m_1V_1^2)(\sqrt{2}-1)^2$$

$$1 = \frac{m_1}{m_2}(\sqrt{2}-1)^2$$

$$\therefore \frac{m_2}{m_1} = (\sqrt{2}-1)^2 = 0.1716 \quad (1)$$

(ii) since $\frac{m_2}{m_1} < 1$, m_1 is more massive than m_2. (2)

(c) (i) The impulse is the area under the curve

$$I = 2 \times \left[\frac{1}{2}(m+n)h\right] \quad (3)$$

$$= (m+n)h = (10+30) \times 1 = 40\,Ns //$$

(ii) $I = F\Delta t$

$$\Rightarrow F = \frac{I}{\Delta t} = \frac{40\,Ns}{2s} = 20\,N // \quad (3)$$

(iii) $F_{max} = 30\,N$ (1)

PHI10 TEST 2. 09/2019.

Q2.

(i) Oblique Collision: is when two bodies are not moving along the same straight line path before and after Collision.

(ii) Law of Conservation of linear momentum: States that in the absence of any external force, vector Sum of the linear momentum of a System of particles remains Constant.

$$\vec{P_T} = \vec{P_1} + \vec{P_2} + \vec{P_3} + \cdots + \vec{P_n} = \text{Constant.}$$

(iii) Coefficient of restitution: is the ratio of magnitude of their relative velocity after Collision to the magnitude of their relative velocity before the Collision.

$$e = \frac{|v_1 - v_2|}{|u_1 - u_2|}.$$