PHY 111

ASSIGNMENT 2

SUMMER 21

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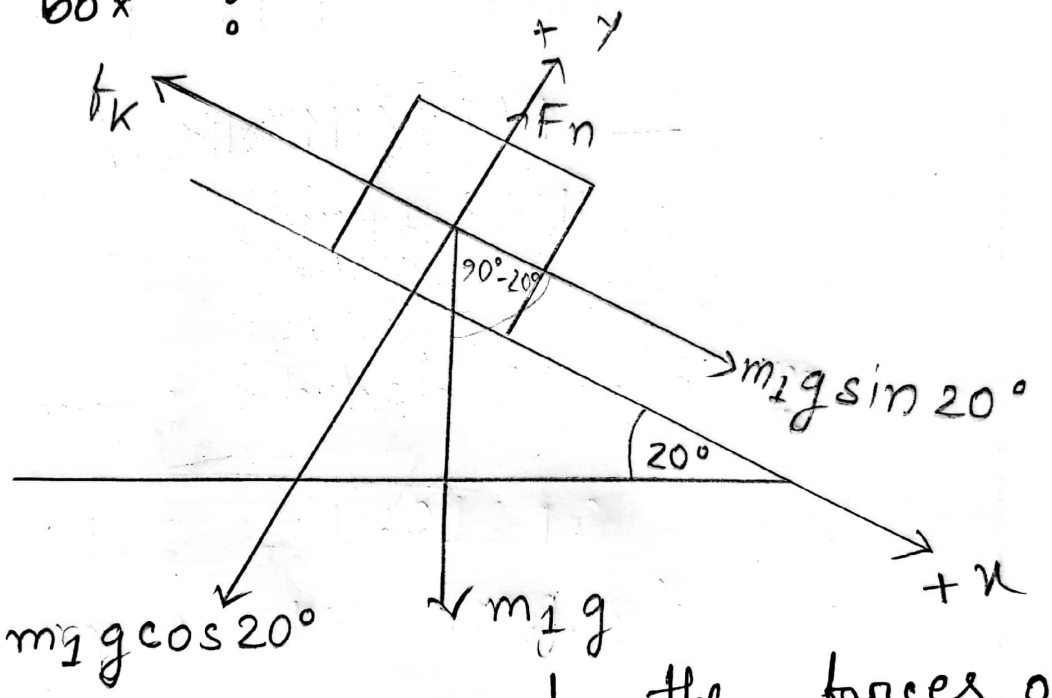
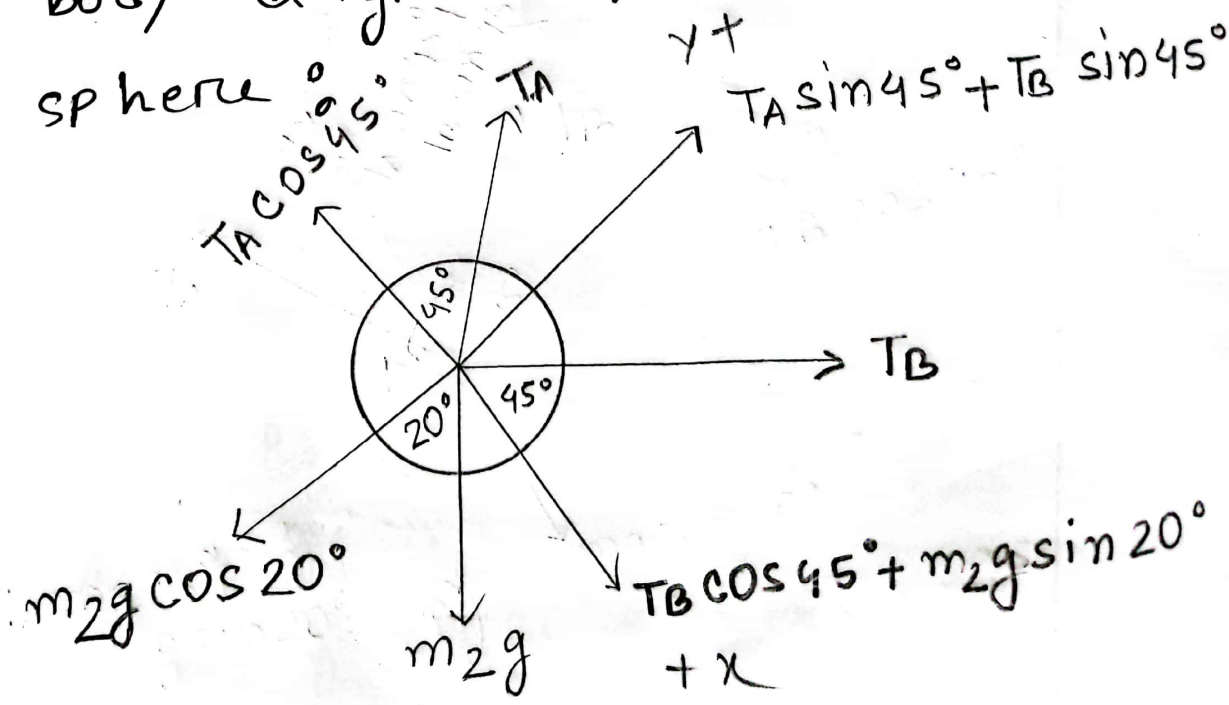
sec: 17 (MSJS)

Ans to the qno 1 (a)

Free body diagram of the forces on the box :



Free body diagram of the forces on the sphere :



Ans to the qr no 1(b)

Given, Mass of the box $= m_1 = 15$ kg

Mass of the sphere, $m_2 = 10$ kg

Total mass $= M = (m_1 + m_2) = 25$ kg

Coefficient of kinetic friction between the box and plane, $\mu_k = 0.15$

For the box, in both x and y axes, applying Newton's 2nd law of force $\vec{F} = m\vec{a}$ we get,

$$F_N - Mg\cos 20^\circ = 0$$

$$\Rightarrow F_n = Mg\cos 20^\circ$$

Component of net force along horizontal -

$$Mg\sin 20^\circ - f_k = M\vec{a}$$

$$\Rightarrow Mg\sin 20^\circ - \mu_k F_N = M\vec{a}$$

$$\Rightarrow \vec{a} = \frac{Mg\sin 20^\circ - \mu_k F_N}{M}$$

$$\Rightarrow \vec{a} = \frac{Mg\sin 20^\circ - \mu_k Mg\cos 20^\circ}{M}$$

$$\Rightarrow \vec{a} = g(\sin 20^\circ - \mu_k \cos 20^\circ)$$

$$\Rightarrow \vec{a} = 9.8\,(\sin 20^\circ - 0.15 \times \cos 20^\circ)$$

$$\Rightarrow \vec{a} = 1.97 \text{ ms}^{-2}$$

Acceleration of the box 1.97 ms^{-2}

Ans to the qr no 1 (c)

Given, Mass of sphere, $m_2 = 10$ kg

Acceleration acts on sphere, $a = 1.97\ ms^{-2}$ [from 1(b)]

Let, Tensions of wires are T_A, T_B.

For the sphere, applying Newton's 2nd law of force in both axes we get:

From the x axis,

$$T_A \sin 45^\circ + T_B \sin 45^\circ = mg \cos 20^\circ$$

$$\Rightarrow T_A + T_B = \frac{10 \times 9.8 \times \cos 20^\circ}{\sin 45^\circ}$$

$$\Rightarrow T_A + T_B = 130.23 \quad \ldots \ldots (1)$$

From y axis,

$$T_B \cos 45° + mg \sin 20° - T_A \cos 45° = ma$$

$$\Rightarrow \cos 45° (T_B - T_A) = ma - mg \sin 20°$$

$$\Rightarrow T_B - T_A = \frac{10 \times (1.97 - 9.8 \times \sin 20°)}{\cos 45°}$$

$$\Rightarrow T_B - T_A = \frac{-13.82}{\cos 45°}$$

$$\Rightarrow T_B - T_A = -19.54 \quad \ldots (ii)$$

After solving equation (i) and (ii),

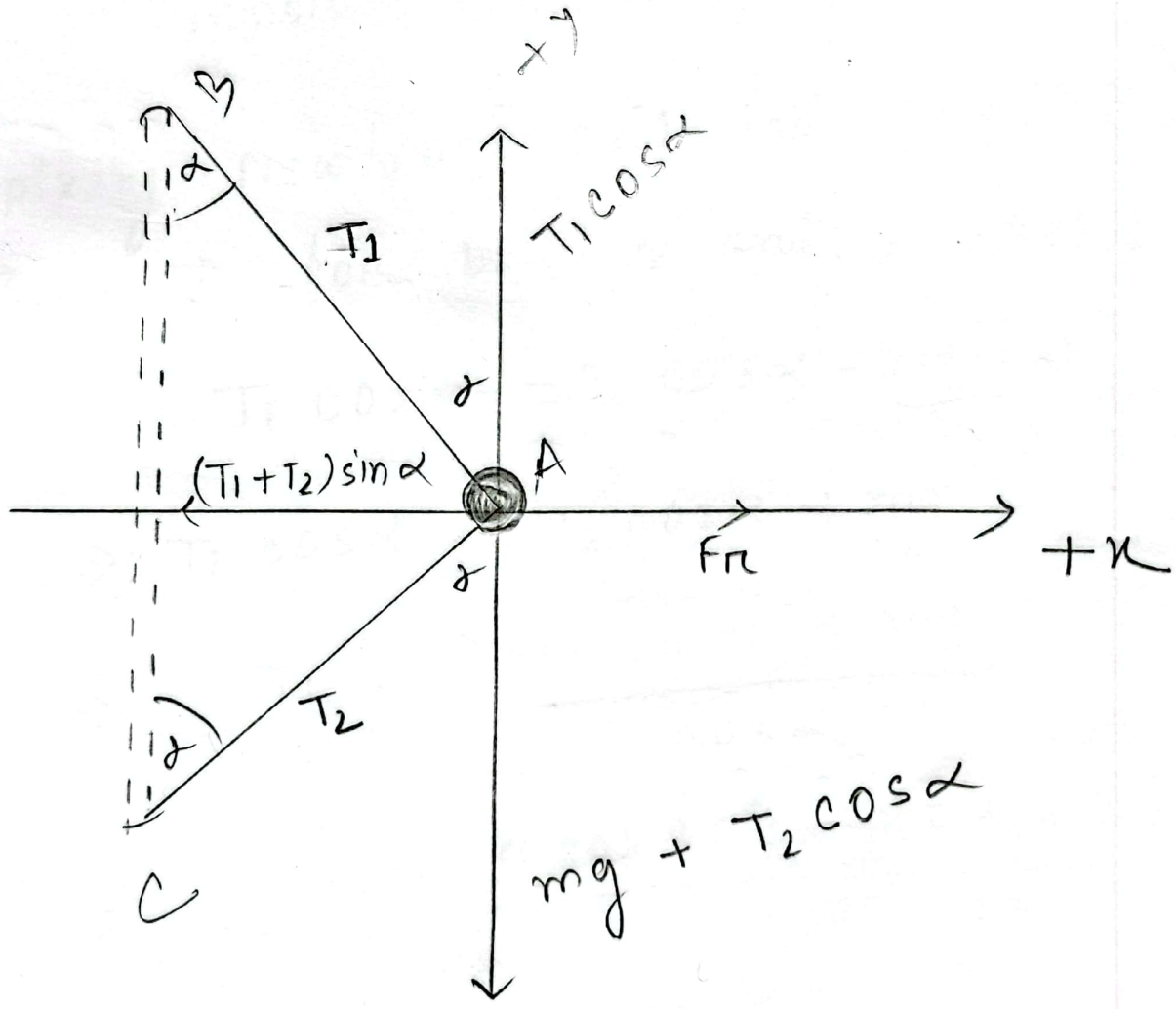
$$T_B = \frac{110.69}{2} = 55.35 \text{ N}$$

And, $$T_A = \frac{149.77}{2} = 74.889 \text{ N}$$

∴ The tension in supporting wire A is, $T_A = 74.89$ N and wire B is $T_B = 55.35$ N

Ans to the qr no 2 (a)

Free body diagram of the forces on the ball :



Ans to the qr no 2 (b)

Given,

Mass of the ball, $m = 200g = 0.2kg$

Tension in the string, AC, $T_2 = 4N$

Applying Newton's 2nd law of force, $\vec{F} = m\vec{a}$ for both x and y axes:

$$T_1 \cos\alpha - T_2 \cos\alpha - mg = 0$$

$$\Rightarrow T_1 \cos\alpha = T_2 \cos\alpha + mg$$

$$\Rightarrow T_1 = \frac{T_2 \cos\alpha + mg}{\cos\alpha}$$

$$\Rightarrow T_1 = \frac{4 \cos 30^\circ + (0.2 \times 9.8)}{\cos 30^\circ}$$

$$\therefore T_1 = 6.26\ N$$

$\therefore$ Tension in string AB is, $T_1 = 6.26N$

Component for net for $\nearrow$ axis -

$$T_1 \sin\alpha + T_2 \sin\alpha - f_R = 0$$

$$\Rightarrow \quad f_R = (T_1 + T_2)\sin\alpha$$

$$\Rightarrow \quad m\vec{a}_R = \frac{(T_1 + T_2)\sin\alpha}{m}$$

$$\Rightarrow \quad \vec{a}_R = \frac{(6.26 + 4)\sin 30^\circ}{0.2}$$

$$\Rightarrow \quad \vec{a}_R = 25.65 \text{ ms}^{-2} \swarrow$$

∴ The radial acceleration is 25.65 ms^{-2}

Ans to the qr no 2 (c)

From q. 2(b) we know,

radial acceleration, $\vec{a}_r = 25.65\ ms^{-2}$

Given length of string $AB = 400\ mm$
$= 0.4\ m$

From the free body diagram,

radius of curvature, $r = AB \sin\alpha$

$\Rightarrow r = 0.4 \sin 30°$

$\Rightarrow \therefore r = 0.2\ m$

We know,

$\vec{a}_r = \omega^2 r$

$\Rightarrow \omega^2 = \frac{\vec{a}_r}{r}$

$\Rightarrow \omega = \sqrt{\frac{\vec{a}_r}{r}}$

$\Rightarrow \omega = \sqrt{\frac{25.65}{0.2}}\ rad\ s^{-1}$

$\therefore \omega = 11.32\ rad\ s^{-1}$

Ans to the or no 2(d)

we know that,

tangential acceleration, $a_t = r \cdot \frac{dw}{dt}$

Since, the ball is in uniform angular speed, $\frac{dw}{dt} = 0$

$\therefore a_t = r \cdot 0$

$\therefore a_t = 0 \ ms^{-2}$

$\therefore$ Reqruired tangential acceleration of the ball is $0 \ ms^{-2}$.