Solution of Assignment-2

Sunday, August 1, 2021 9:32 AM

Principles of Physics-I, PHY111

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1. A 15 kg box frame is sliding down a 20° incline plane with a 10 kg steel sphere suspended inside the box as shown in Fig. 1. Consider the coefficient of kinetic friction between the box and the incline is 0.15.

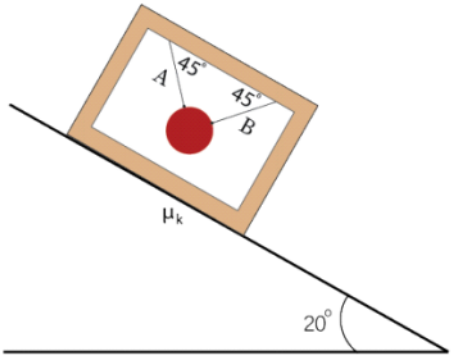
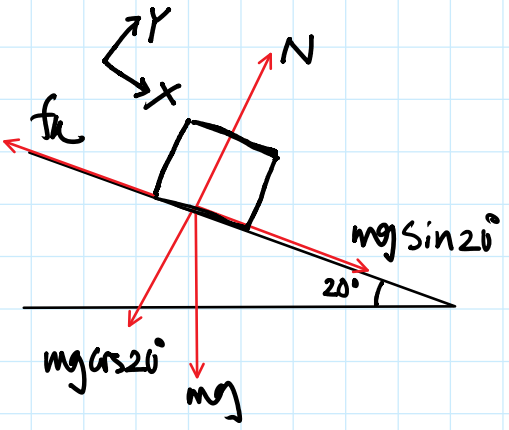


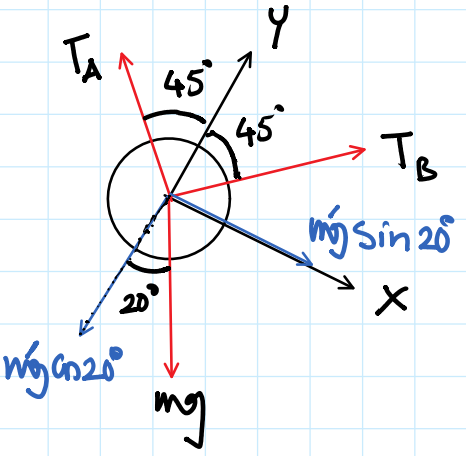
Fig. 1

(a) (2 marks) Draw a free body diagram of the forces on the box and on the sphere.
(b) (3 marks) What is the acceleration of the box?
(c) (5 marks) Calculate the tension in each of the supporting wires A and B.

Soln:- (a)



FBD of Box



FBD of sphere

(b) Box and sphere as a unit

$$\sum F_y = 0$$

$$\Rightarrow N - mg\cos 20^\circ - m'g\cos 20^\circ = 0$$

$$\Rightarrow N = (m+m')g\cos 20^\circ = 25g\cos 20^\circ$$

$$\Rightarrow \boxed{N = 230.22\ N}$$

And. $\Sigma F_x = ma$

$\Rightarrow mg\sin 20^\circ + m'g\sin 20^\circ - f_k = (m+m')a$

$\Rightarrow (m+m')g\sin 20^\circ - \mu_k N = (m+m')a$

$\Rightarrow a = \dfrac{25g\sin 20^\circ - 0.15 \times 230.22}{25}$

$\Rightarrow \boxed{a = 1.97\ m/s^2}$ Ans

(c) Sphere alone

$\Sigma F_y = 0$

$\Rightarrow T_A\cos 45^\circ + T_B\cos 45^\circ - mg\cos 20^\circ = 0$

$\Rightarrow \boxed{T_A + T_B = 130.23\ N}$

And. $\Sigma F_x = ma$

$\Rightarrow T_B\sin 45^\circ - T_A\sin 45^\circ + mg\sin 20^\circ = m'a$

$\Rightarrow \boxed{T_B - T_A = -19.54}$

So. $\boxed{T_A = 74.88\ N}$ and $\boxed{T_B = 55.34\ N}$

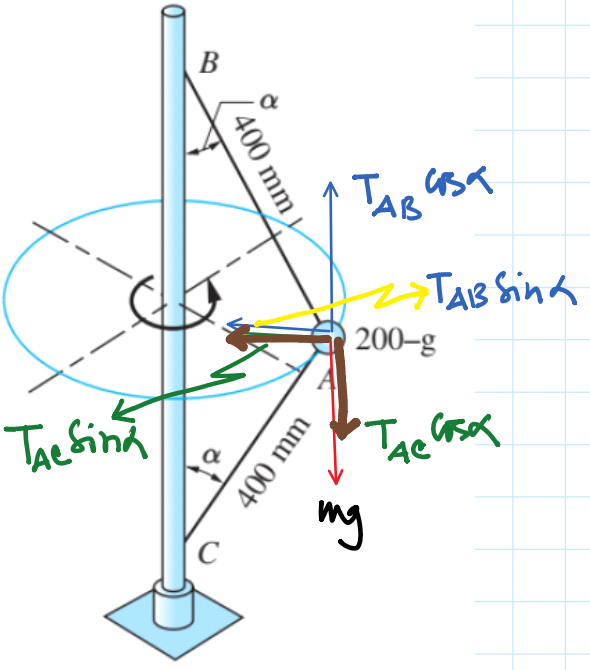
Ans

2. The strings AB and AC connect the 200 g ball to the vertical shaft as shown in Fig. 2. The shaft rotates at a constant angular speed ω and the ball travels in a horizontal circle with the strings inclined at $\alpha = 30^\circ$ to the shaft. Given that the tension in string AC is 4 N.

(a) (2 marks) Draw a free body diagram of the forces on the ball.
(b) (3 marks) Calculate the radial acceleration of the ball.
(c) (4 marks) Find the value of the angular speed ω.
(d) (1 marks) What is the tangential acceleration of the ball?

Soln:-

(a)



FBD

(b) Radial acceleration is a_c.

Here $\Sigma F_y = 0$

$$T_{AB}\cos\alpha - T_{AC}\cos\alpha - mg = 0$$

$$\Rightarrow T_{AB}\cos 30^\circ = mg + T_{AC}\cos 30^\circ$$

$$\Rightarrow T_{AB} = \frac{0.2\times 9.8 + 4\cos 30^\circ}{\cos 30^\circ}$$

$$\Rightarrow \boxed{T_{AB} = 6.26\,N}$$

N.W. $\sum F_n = m a_c$

$\Rightarrow T_{AB} \sin 30^\circ + T_{AC} \sin 30^\circ = m a_c$

$\Rightarrow a_c = \dfrac{T_{AB} \sin 30^\circ + T_{AC} \sin 30^\circ}{m} = 25.65 \text{ m/s}^2$ ✓

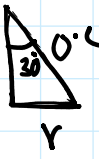
$\Rightarrow \boxed{a_c = 25.65 \text{ m/s}^2}$ Ans

(c) N.W. $a_c = \omega^2 r$

$\Rightarrow \omega = \sqrt{\dfrac{a_c}{r}}$

$\Rightarrow \omega = \sqrt{\dfrac{25.65}{0.2}}$

$\Rightarrow \boxed{\omega = 11.32 \text{ rad/s}}$ Ans



Here,
$r = 0.4 \sin 30^\circ$
$r = 0.2 \text{ m}$

(d) Tangential acceleration is zero. since it rotate at a constant angular speed. Ans