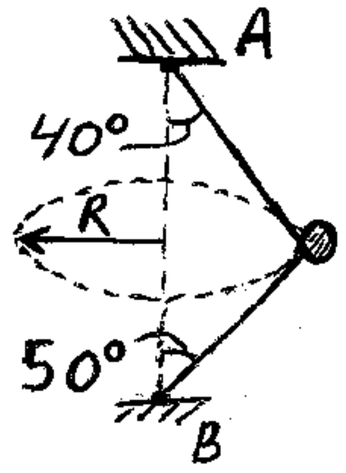
Oct. 5, 2020

This is a force and motion problem involving uniform circular motion.

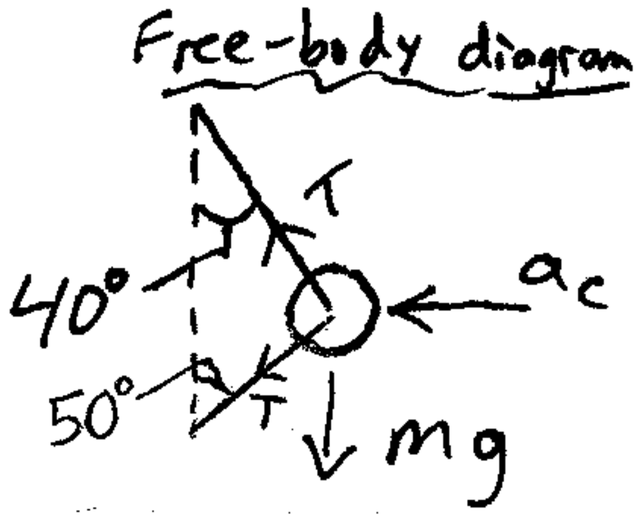


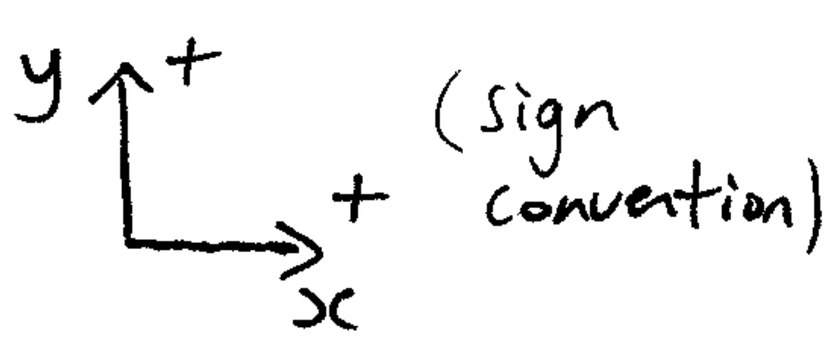
A 3 kg ball is going around in a horizontal circle of radius $R = 2.1\ m$. A single string passes through a ring attached to the ball and is supported at both ends A and B, as shown. Determine the speed of the ball, which is constant.

Solution:

Ignore dimensions of ball

Free-body diagram





Free-body diagram

Apply Newton's second law in x-direction:

$$\Sigma F_x = m a_x \ , \quad m = 3\ kg$$

$$\Rightarrow \ -T\sin 40^\circ - T\sin 50^\circ = m(-a_c)$$

$$a_c = \frac{v^2}{R} \quad , \; R = 2.1 \text{ m}$$

$$\Rightarrow -T(\sin 40^\circ + \sin 50^\circ) = 3\left(\frac{-v^2}{2.1}\right) \qquad (1)$$

Apply Newton's second law in y-direction:

$$\Sigma F_y = m a_y \quad , \; a_y = 0$$

$$\Rightarrow T\cos 40^\circ - T\cos 50^\circ - mg = m(0)$$

$$\Rightarrow T(\cos 40^\circ - \cos 50^\circ) = 3(9.8) \qquad (2)$$

Divide equation (1) by equation (2):

$$\frac{\sin 40^\circ + \sin 50^\circ}{\cos 40^\circ - \cos 50^\circ} = 0.0486\, v^2$$

Solve, $v = 15.34 \text{ m/s}$ (answer)