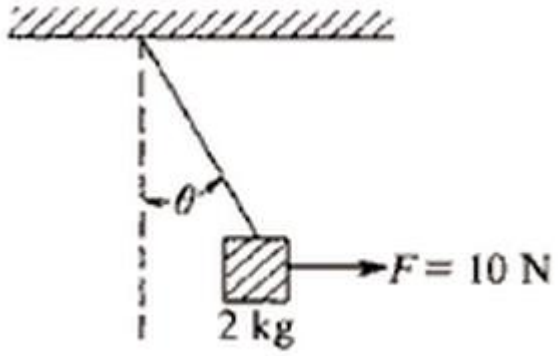
A 2-kilogram box hangs by a massless rope from a ceiling as shown. A force slowly pulls the box horizontally to the side until the force is equal to 10 N. The box is then in equilibrium. The angle that the rope makes with the vertical is closest to:



(a) sin-1(0.5)
(b) tan-1(2.0)
(c) sin-1(2.0)
(d) 45o
(e) tan-1(0.5)

Solution

As box is in equilibrium:

$$\sum \vec{F} = 0$$

So, for horizontal direction:

$$F - T \cdot \sin\theta = 0$$

There T is tension of rope;

For vertical axis:

$$T \cdot \cos\theta - m \cdot g = 0$$

Thus:

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

$$F = T \cdot \sin\theta$$

So:

$$F = \frac{mg}{\cos\theta} \cdot \sin\theta = mg \cdot \tan\theta$$

$$\theta = \arctan\frac{F}{mg}$$

Calculation:

$$\theta = \arctan\frac{10}{2 \cdot 9.8} = \tan^{-1}\frac{10}{2 \cdot 9.8} \approx \tan^{-1} 0.5$$

Answer: (**E)** $\tan^{-1} 0.5$