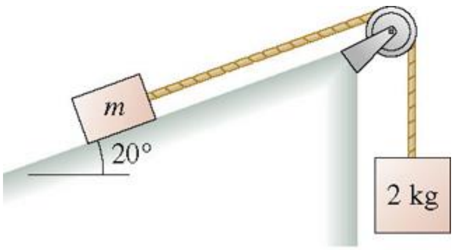
Answer on Question #48063-Engineering-SolidWorks-CosmoWorks-Ansys

Figure shows a block of mass m resting on a 20° slope. The block has coefficients of friction $\mu_s = 0.81$ and $\mu_k = 0.45$ with the surface. It is connected via a massless string over a massless, frictionless pulley to a hanging block of mass $m_2 = 2.0\ kg$.

If this minimum mass is nudged ever so slightly, it will start being pulled up the incline. What acceleration will it have?

Solution



On a 20° slope, the force parallel causes acceleration down the incline

$$F_p = m \cdot g \cdot \sin\theta = m \cdot 9.8 \cdot \sin 20°.$$

The friction force is caused by the force perpendicular $m \cdot g \cdot \cos\theta$ is

$$F_{fr} = \mu_s m \cdot g \cdot \cos\theta = 0.81 \cdot m \cdot 9.8 \cdot \cos 20° \ .$$

Since you are trying to move the block up the slope, both of these forces are opposing motion:

$$F_p + F_{fr} = m \cdot 9.8 \cdot \sin 20° + 0.81 \cdot m \cdot 9.8 \cdot \cos 20° = m \cdot 9.8(\sin 20° + 0.81 \cdot \cos 20°).$$

The force caused by the 2 kg is $F = 2 \cdot 9.8 = 19.6\ N$ pulling the block up the slope.

The block will stick and not slip, if the sum of the down forces is less than 19.6 N.

$$m \cdot 9.8(\sin 20° + 0.81 \cdot \cos 20°) < 19.6.$$

$$\mathrm{m} < \frac{19.6}{9.8(\sin 20° + 0.81 \cdot \cos 20°)}.$$

$$\mathrm{m} < 1.81\ \mathrm{kg}.$$

If this minimum mass is nudged ever so slightly, it will start being pulled up the incline. What acceleration will it have?

We need this kinetic friction force:

$$F_k = \frac{\mu_k}{\mu_s} F_{fr} = \frac{\mu_k}{\mu_s} \mu_s m \cdot g \cdot \cos\theta = \mu_k m \cdot g \cdot \cos\theta = 0.45 \cdot 1.81 \cdot 9.8 \cdot \cos 20°.$$

So,

$$19.6 - 1.81 \cdot 9.8(\sin 20° + 0.45 \cdot \cos 20°) = 1.81 \cdot a.$$

$$a = 3.3 \frac{m}{s^2}.$$

Answer: $\mathbf{3.3} \frac{m}{s^2}$.