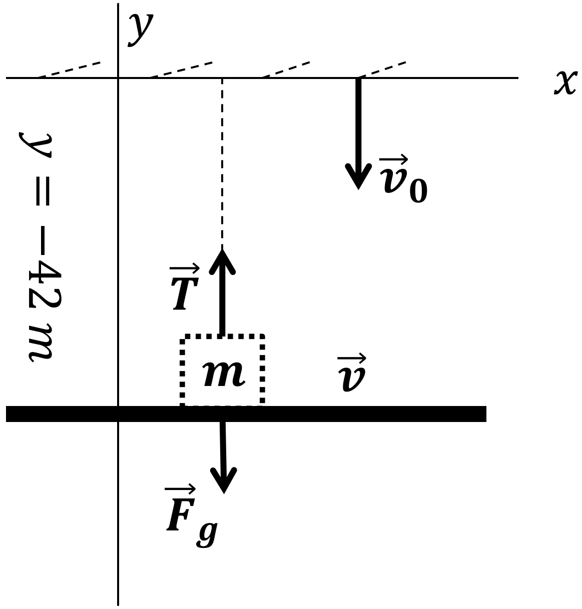
LESSON 5

BOOK CHAPTER 5
(Force and Motion-I)
And
BOOK CHAPTER 6
(Force and Motion-II)

Problem 33 (Book chapter 5):

An elevator cab and its load have a combined mass of 1600 kg. Find the tension in the supporting cable when the cab, originally moving downward at 12 *m/s,* is brought to rest with constant acceleration in a distance of 42 m.



Answer:

We have from Newton's second law,

$$T - mg = ma$$

$$T = ma + mg = m(a + g) = 1600(a + 9.8)$$

To find a, we use the following formula,

$$v^2 = v_0^2 + 2ay$$

$$0 = (-12)^2 + 2a(-42)$$

$$0 = 144 - 84a$$

$$84a = 144$$

$$\boldsymbol{a = 1.714\ m/s^2}$$

Therefore,

$$T = 1600(1.714 + 9.8)$$

$$T = 1600(1.714 + 9.8)$$

$$\boldsymbol{T = 18,422\ N}$$

Here, $v_0 = -12\ m/s$

$v = 0\ m/s$

$m = 1600\ kg$

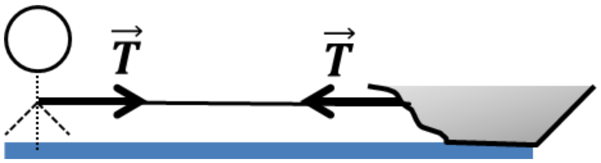
$y = -42\ m$

$T = ?$

Problem 37 (Book chapter 5):

A 40 kg girl and an 8.4 kg sled are on the frictionless ice of a frozen lake, 15 m apart but connected by a rope of negligible mass. The girl exerts a horizontal 5.2 N force on the rope. What are the acceleration magnitudes of (a) the sled and (b) the girl? (c) How far from the girl's initial position do they meet?

Answer:



Since the rope is of negligible mass, the pulls at both ends of the rope have the same magnitude *T.*

(a) For girl

From Newton’s second law,

$$\boldsymbol{T = m_g a_g}$$

[where, $m_g \rightarrow mass\ of\ the\ girl$

$a_g \rightarrow acceleration\ of\ the\ girl$

and $T \rightarrow magnitude\ of\ the\ tension\ force\ along\ the\ rope]$

$$a_g = \frac{T}{m_g} = \frac{5.2}{40} = 0.13\ m/s^2$$

(b) For sled

From Newton’s second law,

$$\boldsymbol{T = m_s a_s}$$

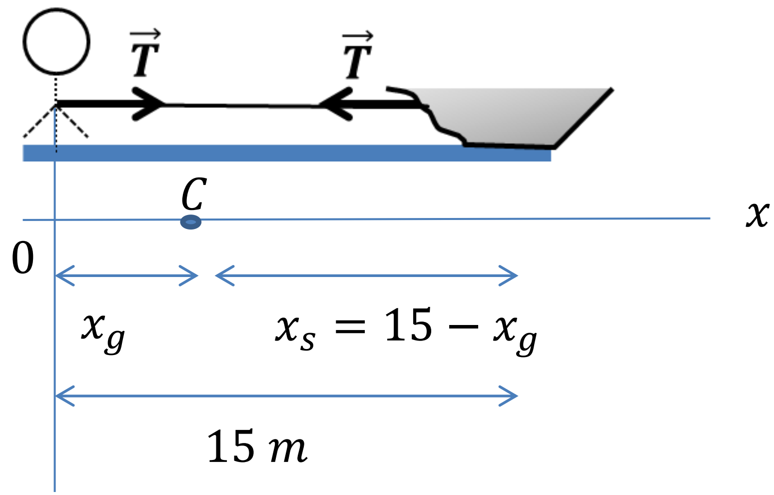
[where, $m_s \rightarrow mass\ of\ the$ sled

$a_s \rightarrow acceleration\ of\ the$ sled]

$$a_s = \frac{T}{m_s} = \frac{5.2}{8.4} = 0.619\ m/s^2$$

(c) We assume that they will meet at point C after a time t.

For girl,



$$x_g = 0 + \frac{1}{2}a_g t^2$$ [since initial velocity of girl is zero]

$$x_g = \frac{1}{2}a_g t^2$$

For sled,

$$-(15 - x_g) = -\frac{1}{2}a_s t^2$$ [since the displacement and acceleration are negative to x axis]

$$15 - \frac{1}{2}a_g t^2 = \frac{1}{2}a_s t^2$$

$$15 - \frac{0.13}{2}t^2 = \frac{0.619}{2}t^2$$

$$15 - 0.065t^2 = 0.3095t^2$$

$$0.3745t^2 = 15$$

$$\boldsymbol{t = 6.329\ s}$$

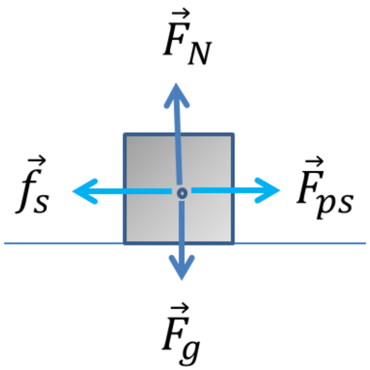
Therefore,

$$\boldsymbol{x_g = \frac{0.13}{2}(6.329)^2 = 2.604\ m}$$

BOOK CHAPTER 6

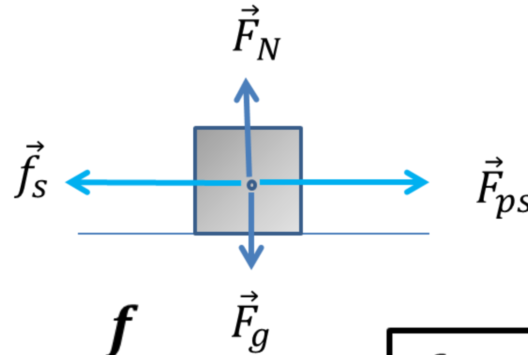
(Force and Motion-II)

Properties of friction:



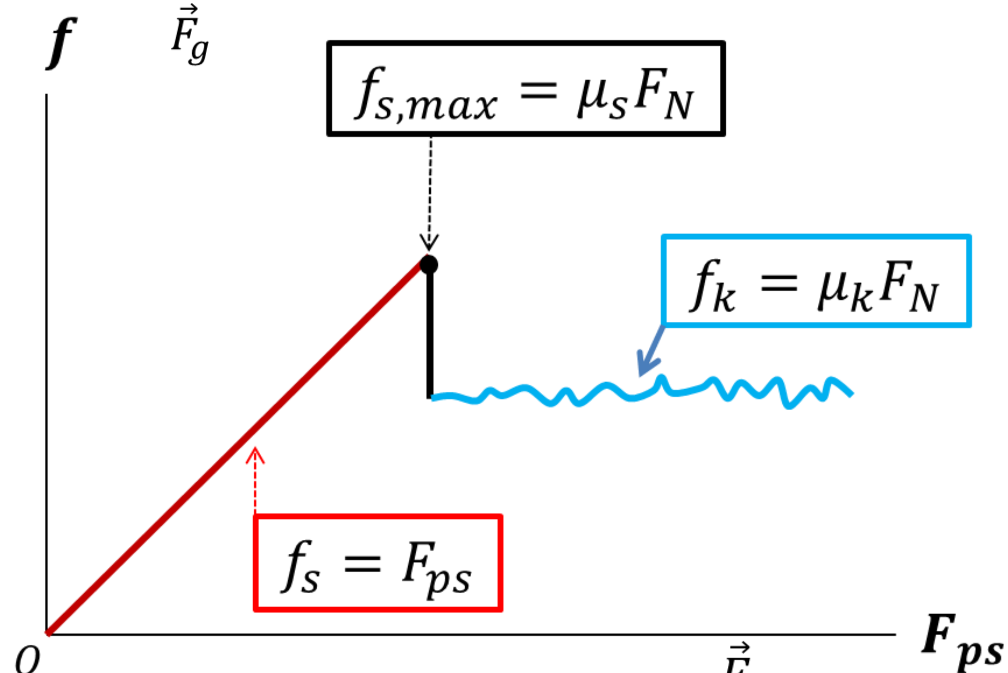
Weak applied force, box remains at rest.

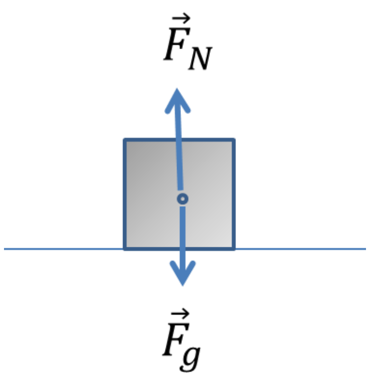
$$F_{ps} = f_s$$



Stronger applied force, box just about to slide.

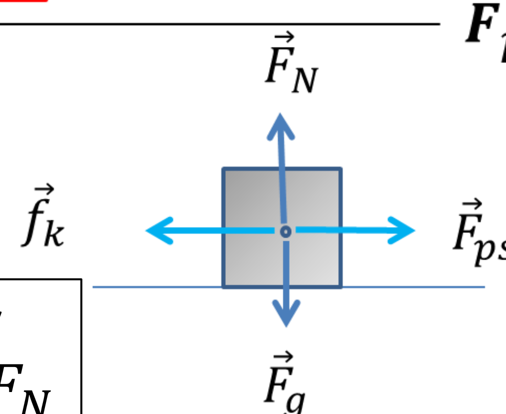
$$f_{s,max} = \mu_s F_N$$





No applied force, box at rest.

No friction, $f_s = 0$



Box sliding at approximately constant speed: $f_k = \mu_k F_N$

Friction: When a force tends to slide a body along a surface, a **frictional force** from the surface acts on the body. The frictional force is parallel to the surface ($\vec{\boldsymbol{F}}_{\boldsymbol{ps}}$) and directed so as to oppose the sliding. It is due to bonding between the body and the surface.

If the body does not slide, the frictional force is a **static frictional force ($\vec{\boldsymbol{f}}_{\boldsymbol{s}}$)**.

If there is sliding, the frictional force is a **kinetic fiictional force ($\vec{\boldsymbol{f}}_{\boldsymbol{k}}$)**.

Properties of Friction:

- If a body does not move, the static frictional force ($\vec{f}_s$) and the applied force parallel to the surface ($\vec{F}_{ps}$) are equal in magnitude, and $\vec{f}_s$ is directed opposite to that $\vec{F}_{ps}$. If the F_{ps} increases, f_s also increases.

- The magnitude of $\vec{f}_s$ has a maximum value $f_{s,max}$ that is given by

$$f_{s,max} = \mu_s F_N$$

where μ_s is the **coefficient of static friction** and F_N is the magnitude of the normal force on the body from the surface. If the magnitude of the $\vec{F}_{ps}$ exceeds $f_{s,max}$, then the body begins to slide along the surface.

- If the body begins to slide along the surface, the magnitude of the frictional force rapidly decreases to a value f_k given by

$$f_k = \mu_k F_N$$

where μ_k is the **coefficient of kinetic friction.** Thereafter, during the sliding, a kinetic frictional force with magnitude f_k opposes the motion.

Thank You