Fri: HW by 5pm

Ex 211, 212, 213, 215, 217, 219, 223, 229

Group Exercise

Mon: Warm Up 8

Thurs: Seminar 12:30

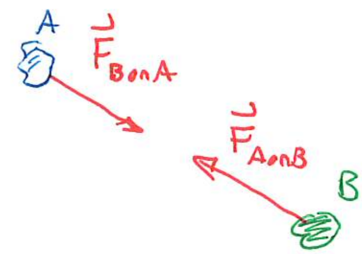
WS 131

Newton's Third Law

Newton's third law constrains the interaction between two objects.

If A exerts a force on B then

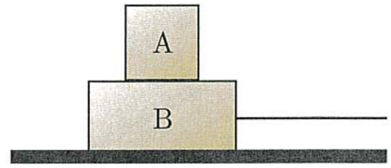
1) B exerts a force on A
2) the forces are exactly opposite (i.e. have equal magnitude but opposite directions)



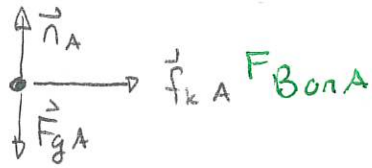
Thus $\vec{F}_{B\,on\,A} = -\vec{F}_{A\,on\,B}$

221 Slipping stacked objects

Two boxes are stacked and move along a frictionless horizontal surface as illustrated. Block A has mass 2.0 kg and block B has mass 3.0 kg. A rope is attached to block B and pulls horizontally with a 50 N force. The coefficient of friction between block A and block B is 0.25. Determine the acceleration of each block, assuming that they both move right and that B moves faster than A. *(131F2024)*



Block A



$\sum F_{ix} = m_A a_x \Rightarrow f_{kA} = m_A a_A$

$\sum F_{iy} = m_A a_y = 0 \Rightarrow n_A - m_A g = 0$

Thus $n_A = m_A g = 2.0\,kg \times 9.8\,m/s^2 = 19.6\,N$

$f_{kA} = \mu_k n_A = 0.25 \times 19.6\,N = 4.9\,N$

$\Rightarrow f_{kA} = \mu_k m_A g$

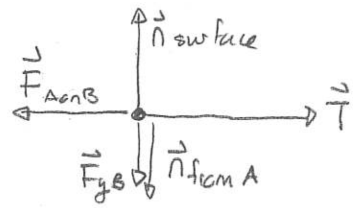
$\Rightarrow \mu_k m_A g = m_A a_A$

$4.9\,N = 2.0\,kg\, a_A$

$\Rightarrow a_A = \mu_k g$

$\Rightarrow a_A = 0.25 \times 9.8\,m/s^2 = 2.45\,m/s^2$

Block B



$\sum F_{ix} = m_B a_{Bx}$

$\sum F_{iy} = m_B a_{By} = 0$

$\sum F_{ix} = m_B a_{Bx} \Rightarrow T - F_{A\,on\,B} = m_B a_B \Rightarrow T - F_{A\,on\,B} = 3\,kg\, a_B$ ~~50N~~ 4.

But $F_{A\,on\,B} = F_{B\,on\,A} = f_{kA} = \mu_k m_A g$

$\Rightarrow T - \mu_k m_A g = m_B a_B$

$50\,N - 4.9\,N = 3.0\,kg\, a_B$

$45.1\,N = 3.0\,kg\, a_B$

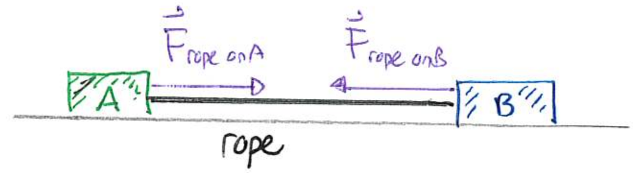
$a_B = 15\,m/s^2$

$\Rightarrow a_B = \dfrac{T - \mu_k m_A g}{m_B}$

$\Rightarrow a_B = \dfrac{50\,N - 0.25 \times 2.0\,kg \times 9.8\,m/s^2}{3.0\,kg} = 15.0\,m/s^2$

Objects connected by ropes.

When two objects are connected by ropes the rope will exert a force on either



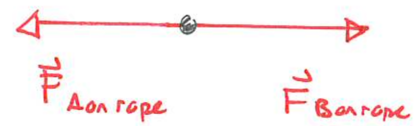
We need to relate the forces exerted at either end of the rope. We consider:

1) ropes that do not stretch
2) ropes that are massless.

If the rope is massless then $\vec{F}_{net} = m\vec{a} = 0$

$$\Rightarrow \vec{F}_{net} = 0$$

$$\Rightarrow F_{\text{A on rope}} = F_{\text{B on rope}}$$



Thus $F_{\text{rope on A}} = F_{\text{rope on B}}$ (magnitudes). Thus the rope exerts the same force on either end. This is the tension in the rope.

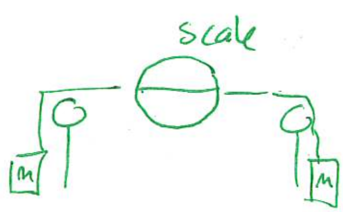
For a massless rope (with no sharp bends) the tension is the same at all points.

Quiz 1 20% – 40%

Quiz 2 —

Quiz 3 10% – 40%

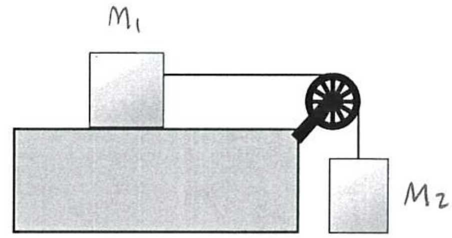
DEMO:



Quiz 4 40%

225 Level/suspended blocks without friction

Two blocks are connected by a string, which runs over a massless pulley. One block, with mass 3.0 kg is suspended and the other block, with mass 7.0 kg can move along a frictionless horizontal surface. The string connected to the block on the surface runs horizontally. *(131Sp2025)*



a) Draw a free body diagram for the *box on the surface.*

b) Write Newton's Second Law in component form for the *box on the surface,* i.e. write

$$F_{\text{net } x} = \Sigma F_x = \cdots \quad (17)$$
$$F_{\text{net } y} = \Sigma F_y = \cdots \quad (18)$$

Insert as much information as possible about the components of acceleration at this stage. The resulting equations will generate much of the algebra that follows.

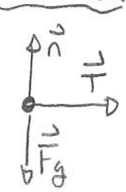
c) List all the components of all the forces for the box on the surface.

d) Use Eqs. (~~21~~) and (~~22~~) and the components to obtain an equation relating the tension in the rope and the acceleration of the box. Can you solve this for acceleration at this stage?

e) Repeat parts a) to d) for the *suspended crate.* Be careful about the acceleration!

f) Combine the equations for the two objects to obtain the acceleration and the tension in the rope.

Answer: a) Surface box



b) $\Sigma F_x = M_1 a_x$

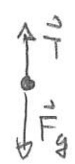
$\Sigma F_y = M_1 a_y = 0$

c)

	x	y
$\vec{T}$	T	0
$\vec{F}_g$	0	$-M_1 g$
$\vec{n}$	0	n

d) $T = M_1 a_x$ cannot solve.

e)



$\Sigma F_y = M_2 a_y \Rightarrow T - M_2 g = M_2 a_y.$

We set $a_x = a$, $a_y = -a$

f) Then $T = M_1 a$ $\quad T - M_2 g = -M_2 a \Rightarrow M_1 a - M_2 g = -M_2 a$

$\Rightarrow (M_1 + M_2) a = M_2 g$

$\Rightarrow a = \dfrac{M_2}{M_1 + M_2} g = \dfrac{3.0\,\text{kg}}{10.0\,\text{kg}} \times 9.8\,\text{m/s}^2 \Rightarrow$ $a = 2.94\,\text{m/s}^2$