Tues: Warm Up 7 (D2L)

Thurs: Discussion /quiz

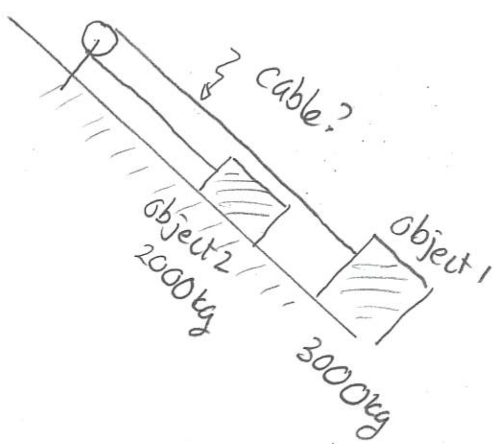
Ex 145, 146, 147, 148, 153, 154, 156

Thurs: Seminar 12:30 -1:30 WS203

Interacting objects

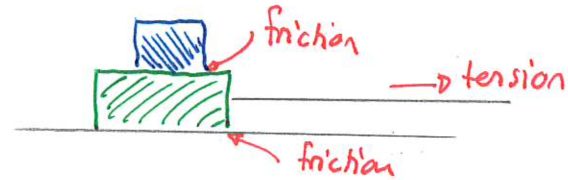
There are physical situations in which two or more objects interact and move. The motion that unfolds can be affected by the interaction.

Objects moving together



Demo: Wikipedia Durquesne Incline

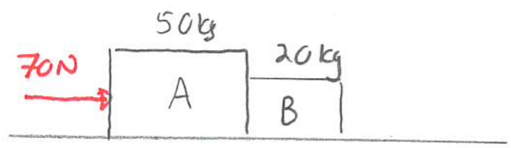
Objects not moving together



* max tension without blue block slipping
* acceleration when this maximum force is exceeded

In such cases we need rules that describe the interactions between the participating objects.

Quiz 1 80% → 100% } 90% – 90%

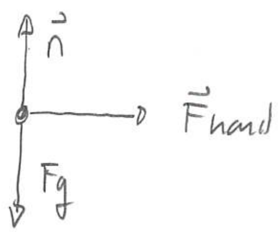


Quiz 2 10% – 10% } 20% – 30%

We can analyze the forces by applying Newtons Second Law to:

1) the combination of the blocks regarded as a single block.
2) each block separately

For the combination, the two blocks have the same acceleration

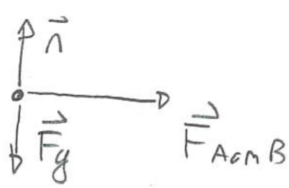


$$\sum F_x = m_{combination} \, a_x$$

$$\Rightarrow F_{hand} = 70kg \; a_x \quad \Rightarrow 70N = 70kg \; a_x$$

$$\Rightarrow a_x = 1 m/s^2$$

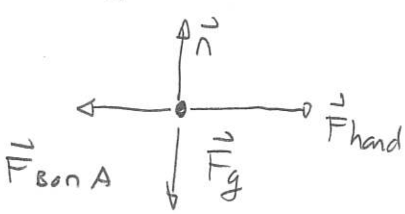
Now consider just block B



$$\sum F_x = m_B \, a_x$$

$$\Rightarrow F_{A on B} = 20kg \times 1.0 m/s^2 \Rightarrow F_{A on B} = 20N$$

Finally consider block A



$$\sum F_x = m_A \, a_x$$

$$F_{hand} - F_{B on A} = m_A \, a_x$$

$$\Rightarrow 70N - F_{B on A} = 50kg \; 1.0 m/s^2$$

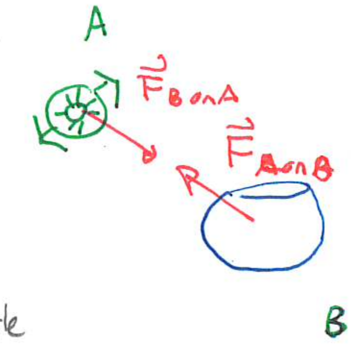
$$\Rightarrow 70N - F_{B on A} = 50N \quad \Rightarrow F_{B on A} = 20N$$

We have seen that each block exerts a force on the other and that the magnitudes of these forces are equal

This is an example of Newton's Third Law

Consider two objects, A and B. Then if object A exerts a force on object B:

1) object B exerts a force on A
2) the force vectors have equal magnitude and opposite direction.



Notes:

1) the pair of forces are called an action-reaction pair
2) the forces act on different objects
3) it is always true that

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

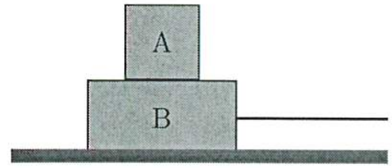
Quiz3 10% → change from surface to "table"
0% →

In general when the two objects move together, they can be analyzed as a single object. Then Newton's Third Law will only be useful when we need information involving the forces that they exert on each other.

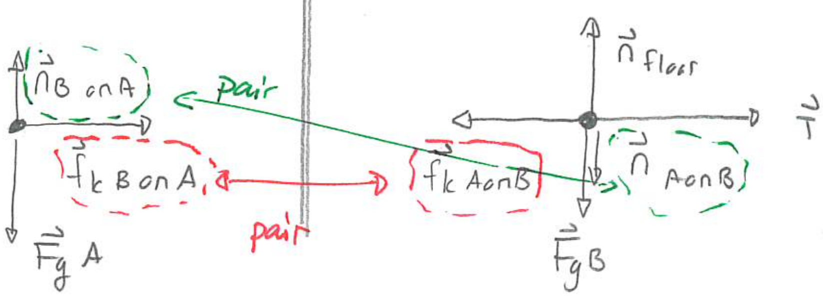
However, when their accelerations are different, Newton's Third Law will be essential.

163 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. *(131Sp2023)*



Block A | Block B



For block A

$$\sum F_x = m_A a_{Ax}$$

$$\sum F_y = m_A a_{Ay} = 0$$

$$\Rightarrow \quad f_{k\,B\,on\,A} = m_A a_{Ax}$$

$$n_{B\,on\,A} - F_{g\,A} = 0$$

$$\boxed{f_{k\,B\,on\,A} = m_A a_{Ax}}$$

For block B

$$\sum F_x = m_B a_{Bx}$$

$$\sum F_y = m_B a_{By}$$

$$\Rightarrow \quad T - f_{k\,A\,on\,B} = m_B a_{Bx}$$

$$n_{floor} - n_{A\,on\,B} - m_B g = 0$$

The crucial equation is

$$\boxed{T - f_{k\,A\,on\,B} = m_B a_{Bx}}$$

These are the two equations that contain the accelerations

The strategy is

$\sum F_y = 0$ for A gives $n_{B\,on\,A}$ $\Rightarrow$ $n_{B\,on\,A} = m_A g$

↓

$n_{B\,on\,A}$ gives $f_{k\,B\,on\,A} = \mu_k n_{B\,on\,A}$ $\Rightarrow$ $f_{k\,B\,on\,A} = \mu_k m_A g$

↓

$f_{k\,B\,on\,A}$ gives a_{Ax} $\Rightarrow$ $f_{k\,B\,on\,A} = m_A a_{Ax}$

$$\mu_k m_A g = m_A a_{Ax}$$

$$\Rightarrow a_{Ax} = 0.25 \times 9.8\,m/s^2 = 2.5\,m/s^2$$

↓

$f_{k\,B\,on\,A}$ gives $f_{k\,A\,on\,B}$ $\Rightarrow$ $f_{k\,A\,on\,B} = f_{k\,B\,on\,A} = \mu_k m_A g$

↓

$f_{k\,A\,on\,B}$ and T give a_{Bx} $\Rightarrow$ $T - f_{k\,A\,on\,B} = m_B a_{Bx}$

$$\Rightarrow T - \mu_k m_A g = m_B a_{Bx}$$

$$\Rightarrow a_{Bx} = \frac{T - \mu_k m_A g}{m_B}$$

$$= \frac{50N - 0.25 \times 2.0kg \times 9.8m/s^2}{3.0kg}$$

$$\Rightarrow a_{Bx} = 15 m/s^2$$