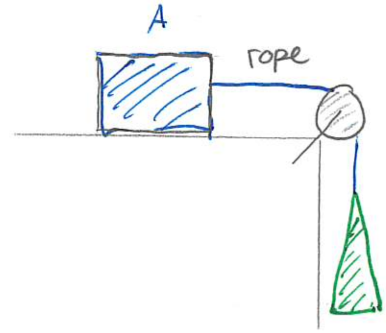
Thurs: Discussion / quiz

Ex ~~144~~, 145, 146, 147, 148
153, 154, 156

Fri:

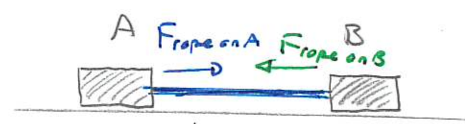
Objects connected by ropes / cables

Objects that move together sometimes do so via a connecting rope. In such situations:



1) there are at least three objects
2) when the rope is massless, its motion does not need to be considered.
3) if there is no bend in the rope, then the tension is the same everywhere.

Consider a situation of two blocks on a horizontal surface. For the moment consider the rope only.

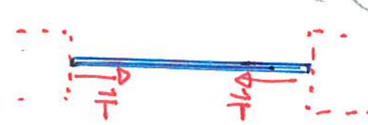


$\sum \vec{F} = m\vec{a} = 0$ since mass of rope is zero

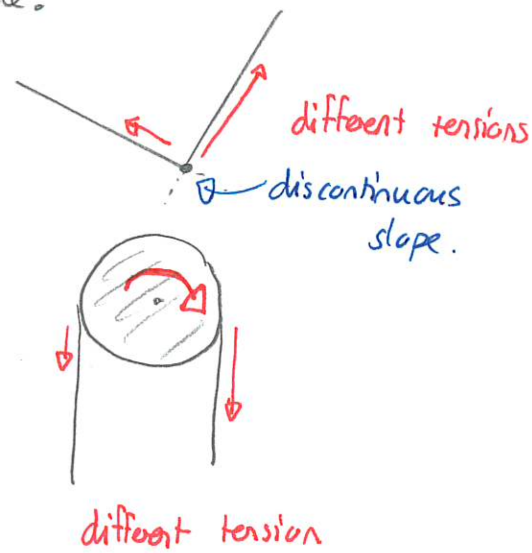
$\Rightarrow F_{B\ on\ rope} = F_{A\ on\ rope}$ (magnitudes)

We can call this force tension. So

> The forces exerted by either end of a massless rope have the same magnitude provided that there are no sharp bends in the rope. The magnitudes of these forces are tension



Note that if there is any mass present anywhere along the rope then the tension can be different on either side.

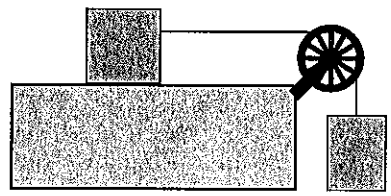


Quiz 1 60% - 95% & 50% - 60%

Warm Up 1

167 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. *(131Sp2023)*



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.

$$F_{gx} = \cdots$$
$$F_{gy} = \cdots$$
$$n_x = \cdots$$
$$n_y = \cdots$$
$$\vdots$$

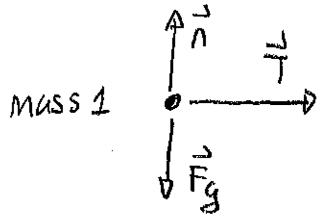
Force	x comp	y comp
$\vec{\mathbf{F}}_g$		
$\vec{\mathbf{n}}$		
$\vdots$		

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)



b) $\sum F_x = m_1 a_{1x}$

$\sum F_y = m_1 a_y = 0$

c)

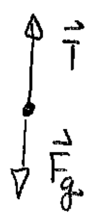
	x	y
$\vec{F_g}$	0	$-m_1 g$
$\vec{n}$	0	n
$\vec{T}$	T	0

d) $\sum F_x = m_1 a_{1x}$

$\Rightarrow T = m_1 a_{1x}$ — (1)

There is not enough information

e)



$\sum F_y = m_2 a_{2y}$ (x does not matter)

	x	y
$\vec{F_g}$	0	$-m_2 g$
$\vec{T}$	0	T

$\sum F_y = m_2 a_{2y}$

$\Rightarrow T - m_2 g = m_2 a_{2y}$ — (2)

We need to combine (1) and (2). However, there are two accelerations and they are related. They have the same magnitude. let the magnitude be a. Then

$a_{1x} = a$

$a_{2y} = -a$ (down...

Thus: (1) gives

$T = m_1 a$

and (2) gives

$T - m_2 g = -m_2 a$

Combining gives

$m_1 a - m_2 g = -m_2 a$

$\Downarrow$

$(m_1 + m_2) a = m_2 g$

$\Downarrow$

$$a = \frac{m_2}{m_1 + m_2} g$$

$$= \frac{3}{10} g = 2.94 m/s^2$$

$\Rightarrow T = 7.0kg\, a$

$\Rightarrow T - 3.0kg \times 9.8m/s^2 = -3.0kg\, a$

$\Downarrow$

$7.0kg\, a - 29.4N = -3.0kg\, a$

$\Downarrow$

$10kg\, a = 29.4N$

$\Rightarrow a = 2.94 m/s^2$

Warm Up 2