Phy 2A 5/3

Monday, May 1, 2017 6:24 PM

Goals for the Lecture:

1) Use Newton's Second Law to solve motion problems, including: multiple objects, incline planes, friction, pulleys, and ropes
2) Understand how to solve circular motion problems and that they are just applications of Newton's Second Law

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From the homework:
While hauling a log in the back of a flatbed truck, you are pulled over by the state police. Although the log can\'t roll sideways, the police claim that the log could have slid out the back of the truck when accelerating from rest. You claim that the truck couldn\'t possibly accelerate at the level needed to achieve such an effect. Regardless, the police write a ticket anyway and now your day in court is approaching.

The log has a mass of m = 974 kg; the truck has a mass of M = 9800 kg. According to the truck manufacturer, the truck can accelerate from 0 to 55 mph (24.59 m/s) in 27.0 seconds, but this does not account for the additional mass of the log. Calculate the minimum coefficient of static friction μs needed to keep the log in the back of the truck.

According to the scientific literature, the coefficient of static friction between the log and the trailer bed should be roughly 0.840. Given this fact, answer the following.

1) empty truck:

$$F = m_{truck}\, a_{empty}$$

$$= (9800)\left(\frac{24.59\ \frac{m}{s}}{27\ s}\right)$$

$$= 8925\ N$$ max force of truck

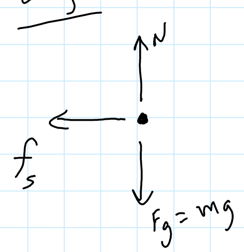
2) Loaded truck:

$$F = m a$$

$$8925 = (m_T + m_{log})\, a_{loaded}$$

$$a_{loaded} = 0.828\ \frac{m}{s^2}$$

3) Log



$$F_{log} = m_{log}\, a_{loaded}$$

$$\mu_s (\cancel{m_{log}}\, g) = \cancel{m_{log}}\, a_{loaded}$$

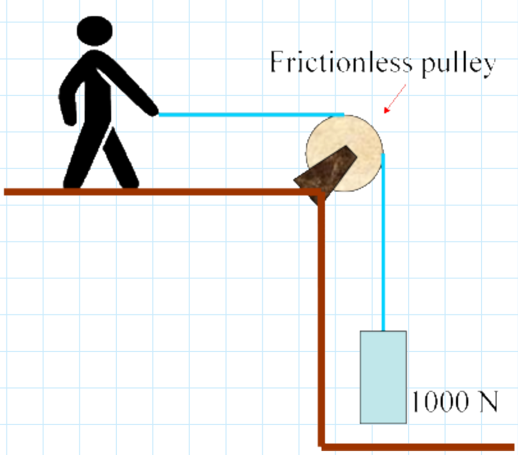
$$\mu_s = \frac{a_{loaded}}{g} = 0.0845$$

$$f_k = \mu_k N$$

Newtons unitless Newtons

Will Not slide off truck

Robert lifts the blue box, which weighs 1000 N, just a little way off the ground and holds it for 2 minutes, as shown. With what force does he have to pull on the rope to hold the box off the ground?



A. 0 N
B. 500 N
C. 1000 N
D. 2000 N
E. None of the Above

FBD for block

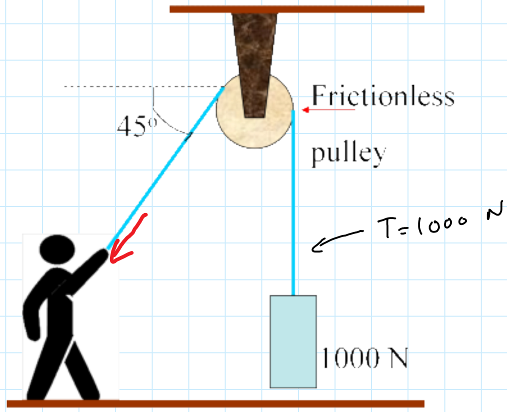
$$\Sigma F = m\cancel{a}^{\,0}$$

$$T - 1000 = 0$$

$$T = 1000 \text{ N}$$

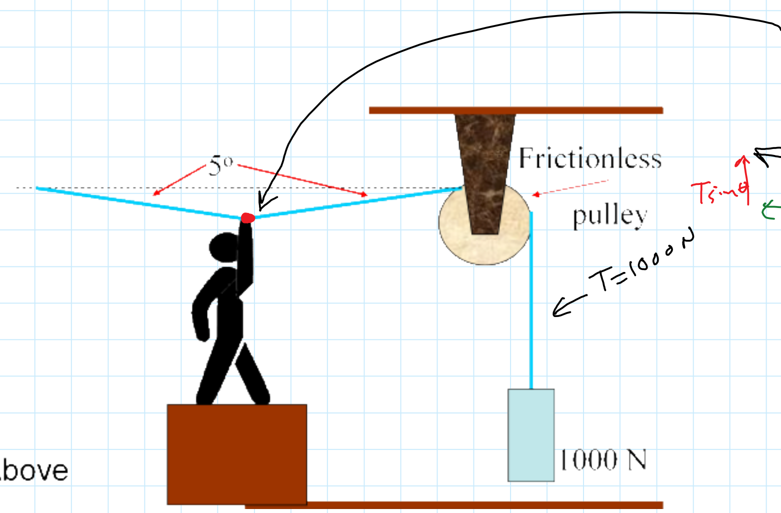
Now, Robert pulls on the rope at an angle. With what force does he have to pull on the rope to hold the box off the ground?

A. 0 N
B. 50 N
C. 500 N
D. 700 N
E. 1000 N
F. 1400 N
G. 2000 N
H. None of the Above

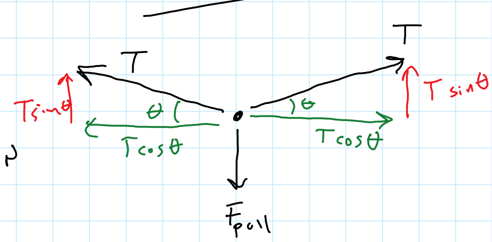


Robert again lifts the 1,000 N weight just a little off the ground using a new technique as shown below. With what force does he have to pull on the rope to hold the box off the ground?

A. 0 N
B. 87.15 N
C. 174.3 N
D. 996.2 N
E. 1000 N
F. 1992 N
G. 2000 N
H. None of the Above



FBD for hand



$\Sigma F_y = 0$

$2(T\sin\theta) - F_{pull} = 0$

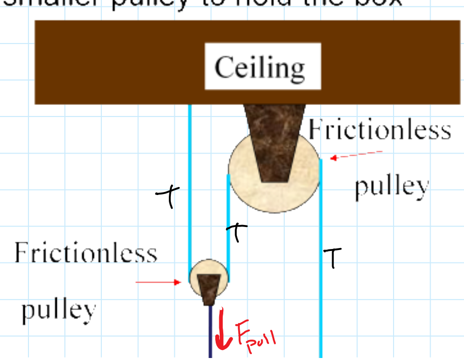
$F_{pull} = 2\ T\ \sin\theta$

$= 2\,(1000)\ \sin 5^\circ$

$= 174\ N$

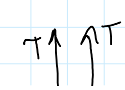
Robert now uses two pulleys to lift the 1000 N weight just a little off the ground as shown. With what force does he have to pull down on the rope attached to the smaller pulley to hold the box off the ground?

A. 0 N
B. 250 N
C. 500 N

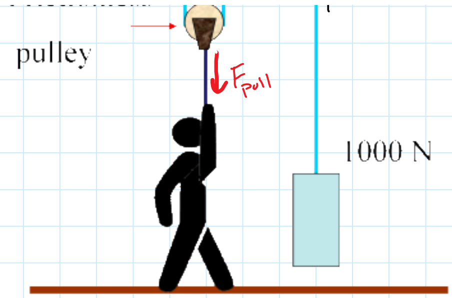


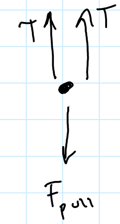
T= 1000 N

FBD for the small pulley



B. 250 N
C. 500 N
D. 1000 N
E. 1500 N
F. 2000 N
G. None of the Above



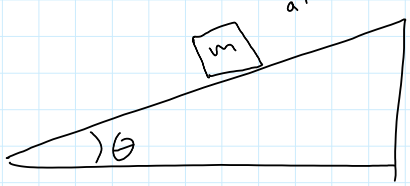


$\Sigma F = 0$

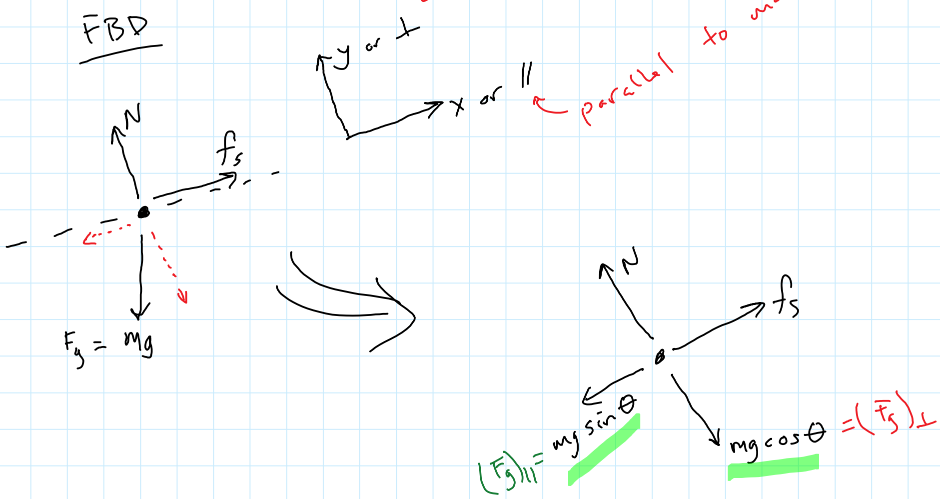
$2T - F_{pull} = 0$

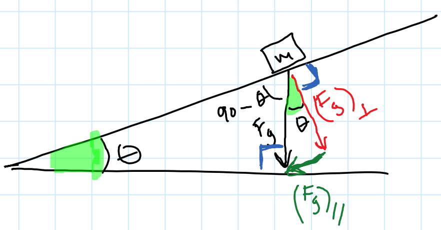
$F_{pull} = 2000$ N

Inclines:

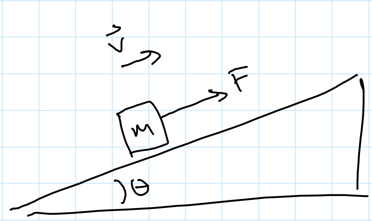


FBD





Find the acceleration of the block:



given: $m = 10$ kg

$\theta = 30°$

$F = 3$ N

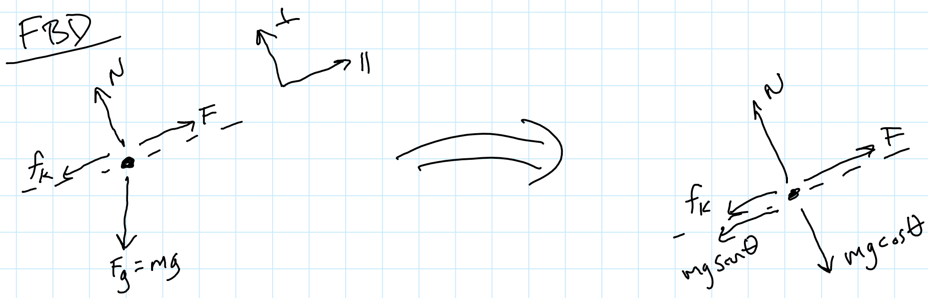
box moving up incline

$\mu_k = 0.2$

FBD

$\mu_k = 0.2$

FBD



$$\Sigma \vec{F} = m\vec{a}$$

$$\Sigma F_{\parallel} = ma \quad \nearrow +$$

$$F - f_k - mg\sin\theta = ma$$

$$F - \mu_k N - mg\sin\theta = ma$$

$$F - \mu_k (mg\cos\theta) - mg\sin\theta = ma$$

$$a = \frac{3 - (0.2)(10)(9.8)\cos 30^\circ - (10)(9.8)\sin 30}{10} = -6.30 \ \frac{m}{s^2}$$

in the neg. direction
or
down the incline

$a_\perp = 0$

$$\Sigma F_{\perp} = 0 \quad \uparrow +$$

$$N - mg\cos\theta = 0$$

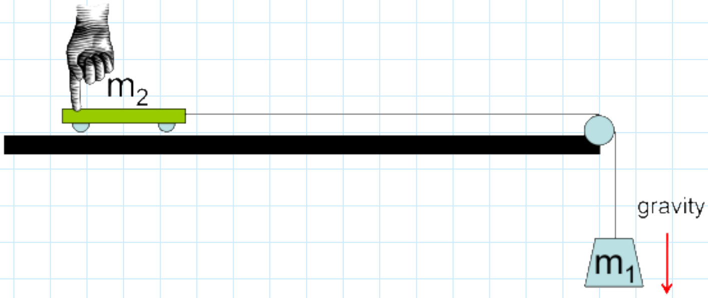
$$N = mg\cos\theta$$

use ⊥ direction to get N

Application of the day:
Inertia:
Horse jumping "refusal"

Video - shopping carts
Video - Normal force swan dive

A cart with mass m_2 is connected to a mass m_1 using a string that passes over a frictionless pulley, as shown below. Initially, the cart is held motionless. The tension in the string is



FBD for m_1

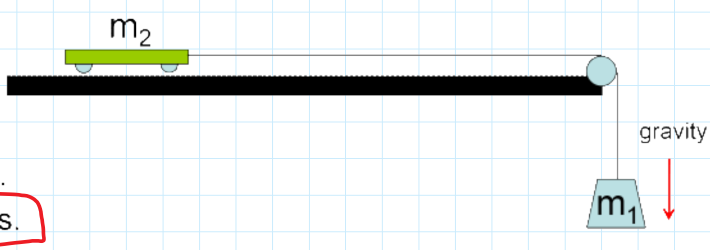
$\Sigma F = m\cancel{a}^{0}$

$T - m_1 g = 0$

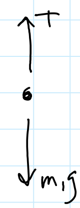
$T = m_1 g$

1. $m_1 g$
2. $m_2 g$
3. $(m_1+m_2)g$
4. $(m_1-m_2)g$
5. Cannot tell from the information given

A cart with mass m_2 is connected to a mass m_1 using a string that passes over a frictionless pulley, as shown below. Initially, the cart is held motionless. After the cart is released, the tension in the string



m_1



1. Increases.
2. Decreases.
3. Remains the same.
4. Cannot tell from the information given.

$\Sigma F = m_1 a$ $\downarrow +$

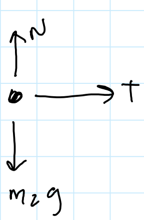
$m_1 g - T = m_1 a$

$\boxed{m_1(g-a) = T}$

Find a in terms of m_1 and m_2:

Need a second equation, use m_2:

M_2



$\Sigma F = m_2 a$ $\rightarrow +$

$T = m_2 a$

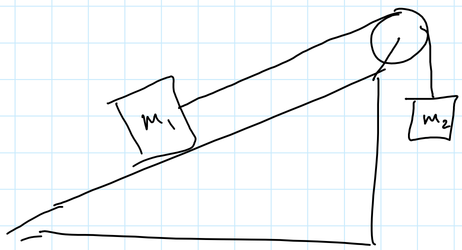
$m_1(g-a) = m_2 a$

$m_1 g - m_1 a = m_2 a$

$m_1 g = (m_1 + m_2) a$

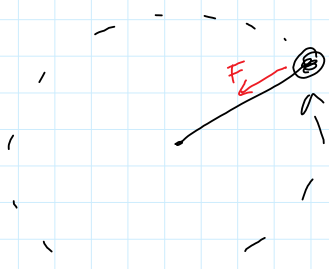
$m_1 g = ($

$$a = \left(\frac{m_1}{m_1+m_2}\right) g$$

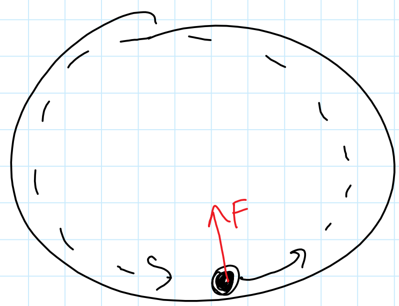


Circular motion: Centripetal force (radially inward)

mass on a string



ball rolling inside a hoop



For circular motion: $a_{cp} = \dfrac{V^2}{R}$

or

$$F = ma$$

so,

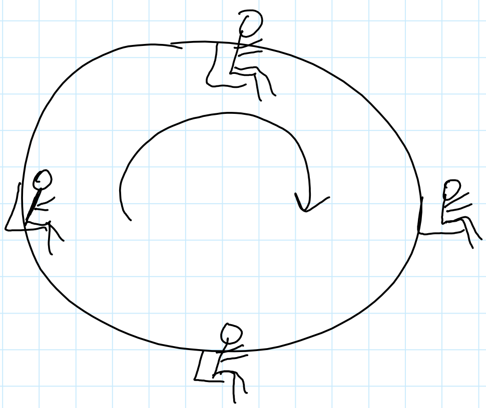
$$F_{cp} = \frac{mv^2}{R}$$

when something moves in a circular path:

$$\Sigma F_{radial} = m\, a_{cp} = m \frac{v^2}{R}$$

could be - friction
- tension
- Normal force
- gravity

or combinations of those



at bottom of Loop:

FBD for person

for circular motion: $\Sigma F_{radial} = m a_{cp}$ $\uparrow +$ toward center of circle

$$N - mg = m\frac{v^2}{R}$$

$$N = \frac{mv^2}{R} + mg$$

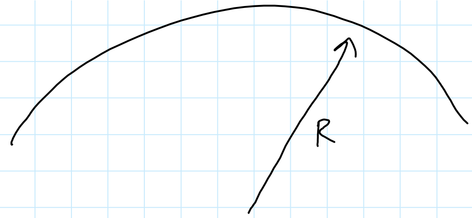
Top of loop

$$\Sigma F_{radial} = m a_{cp} \quad \downarrow +$$

$$mg - N = \frac{mv^2}{R}$$

$$N = mg - \frac{mv^2}{R}$$

Car over speedbump:



if given: R, m

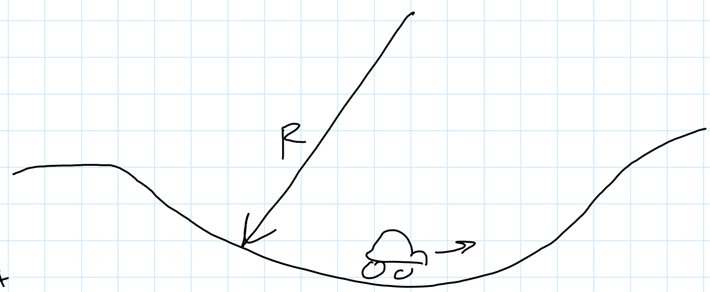
find : V_{max}

and

Apparent weight at V_{max}

OR

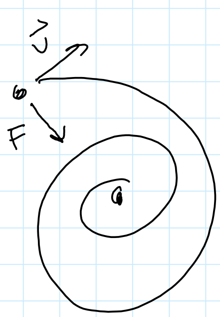
dip in the road :



given: use V_{max}, R, m from above

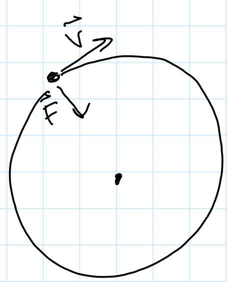
find : apparent weight

We will do these in class next time



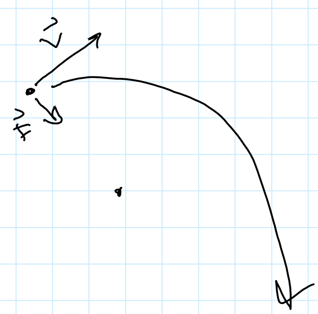
if $F > \frac{mv^2}{R}$

Spirals In



if $F = \frac{mv^2}{R}$

Circular Motion



if $F < \frac{mv^2}{R}$

Spirals Out