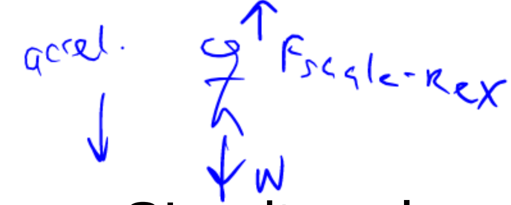
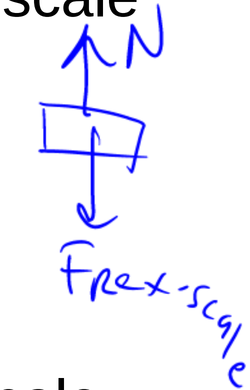
Announcements – 19 Sep 2013

1. **Exam 1 results**
   a. You will get back the exam soon (Friday?)--pick up your exams in the "turn back" boxes (open boxes at the top), near N357 ESC, sorted by first two numbers of CID
   b. Solutions will be posted on website soon (Friday?)
2. **If you have questions** on the exam:
   a. Look over your own exam
   b. Look over the posted solutions
   c. If you can't figure things out after that, come talk to TAs or me
3. **HW 6** (due Tuesday) will require free body diagrams to be turned in for some problems. **Use forms at end of syllabus**.
   a. Read the "Free Body Diagrams" page in the syllabus.
   b. Turn them in to the "turn in" boxes near N357 ESC (closed boxes)
   c. They'll be returned to the "turn back" boxes (cubbyholes)

Elevators (from last time)



Rex has a mass of 40 kg (weight = 392 N), and stands on a SI-unit scale in the elevator.



a. The elevator is at rest. What does the scale read?

$\sum F_{Rex} = 0 \qquad F_{scale-Rex} - W = 0 \qquad F_{scale} = 392\,N$

b. The elevator **accelerates downward** at 2 m/s^2. What does the scale read now?

$\sum F_{Rex} = ma$

$F_{scale-Rex} - W = m(-2\,m/s^2)$

$F_{scale} = W - m(2\,m/s^2) = 392\,N - (40)(2)\,N = 312\,N$

c. After a while the elevator moves down at a **constant speed** of 8 m/s. What does the scale read now?

$a = 0 \qquad F_{scale} = 392\,N$

d. What happens when the elevator begins to stop?

$a =$ positive $\qquad F_{scale} = W +$ something $=$ more than his weight!

Try it out! The elevators in the Eyring building (sometimes) have scales in them!

Newton's 1st Law, revisited

Forces, not Actions

"Objects will continue to move at *constant velocity* unless acted upon by an outside force."

"Objects at rest will remain at rest, and objects in motion will remain in constant, straight-line motion, unless acted upon by an outside force"

From warmup

The force required to maintain an object at a constant speed in free space is equal to

a. the mass of the object
b. the weight of the object
c. zero
d. the force required to stop it
e. none of the above

Demos

Demo: Tablecloth jerk
Demo: Inertia Hoop and Pen
Demo: David and Goliath ball

Video: Shifted air track

Clicker quiz: Relative to the table, how will the glider move?

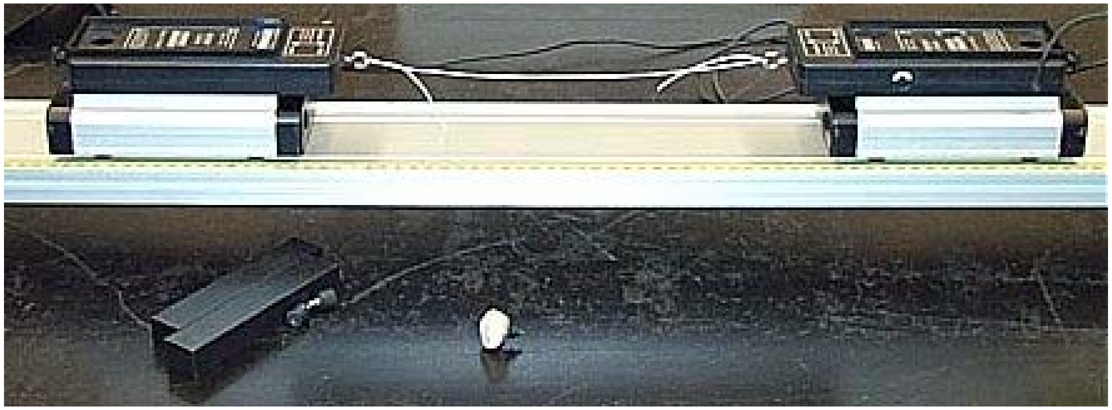
a. It will move left when the track moves left
b. It will move right when the track moves left
c. It will stay motionless as the track moves left

Newton's 3rd Law, revisited

$$\vec{\mathbf{F}}_{12} = -\vec{\mathbf{F}}_{21}$$

"For every force, there is an equal and opposite partner force"

Demo: Force-sensing carts



Clicker quiz: Two carts run into each other. Each cart has a force sensor. How do the forces' magnitudes compare?

a. They are the same
b. It depends which cart is heavier
c. It depends if they bounce or stick
d. It depends in which direction they are accelerating

Newton's 2nd Law, revisited

$$\sum \vec{\mathbf{F}} = m\vec{\mathbf{a}}$$

Different types of forces:

- Gravity (weight)
- Normal force
- Regular push or pull
- Friction
- Rope (tension)
- Springs

Clicker quiz

To solve a “Newton’s second law problem”, the first thing you should do after reading the problem is:

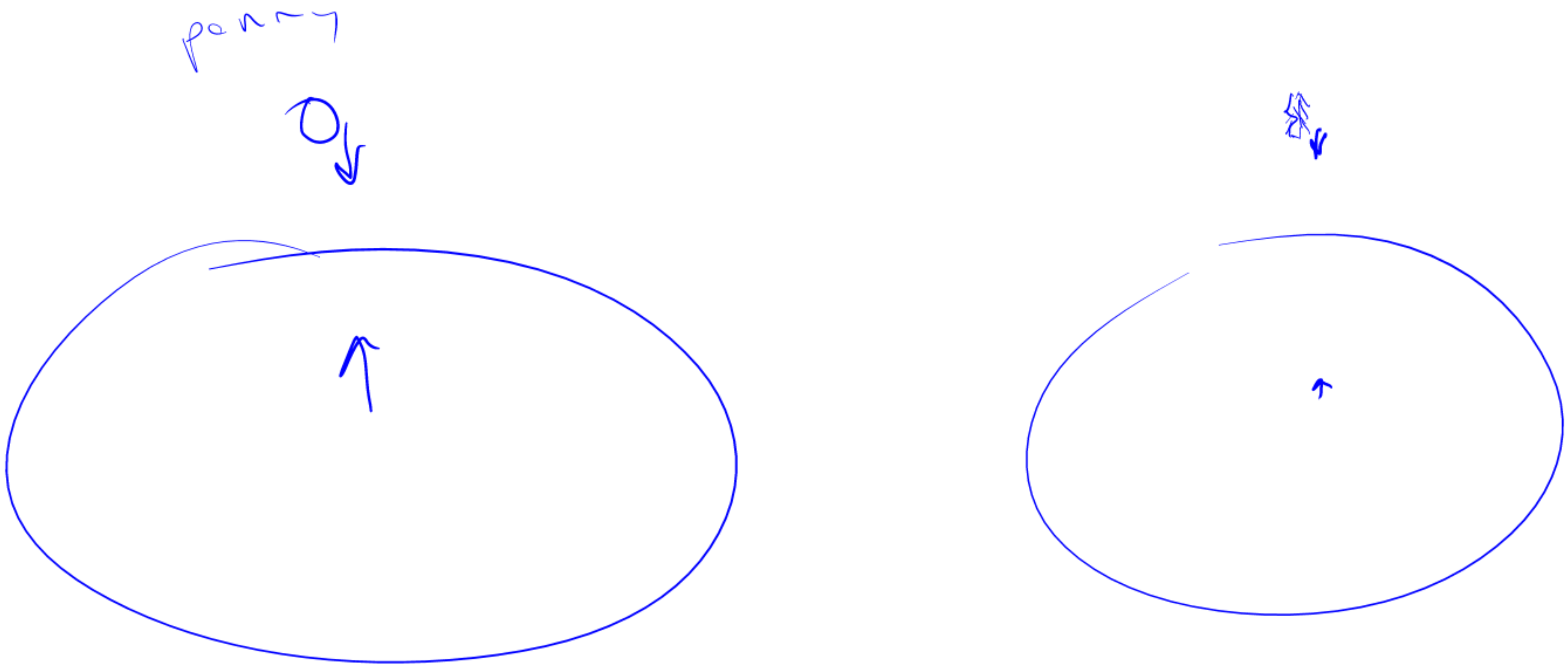
a. Draw a picture/free body diagram
b. Write down the “blueprint equation”
c. Plug the forces into the left-hand side of N2
d. Determine the acceleration
e. Use kinematics equations

From warmup

Ralph was thinking about the demo with the penny and feather falling in a vacuum. The penny and feather both fell at the same rate. He asked, "Does this mean that the force on the penny and the force on the feather are equal?" What would be a good answer (and explanation) to his question?

“Pair share”–I am now ready to share my neighbor’s answer if called on.

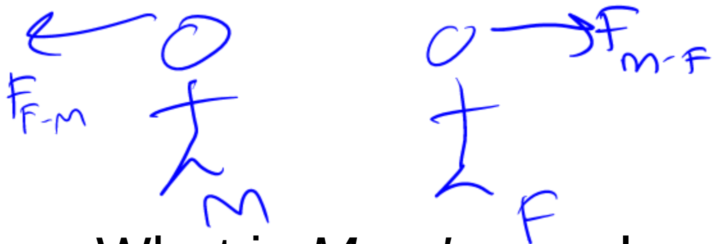
a. Yes



Worked Problem

Mary (40 kg) and Fred (60 kg) have an argument on frictionless ice. Mary pushes Fred with a force of 120 N (27 lbs) for 0.5 second

What is Fred's acceleration while she pushes him?



120 N, .5 sec.

$\sum \vec{F}_x = m\vec{a}_x$

$120\,N = 60\,kg\ a$

$a = 2\ m/s^2$

What is *Mary's* acceleration while she pushes him?

$\sum F_x = ma_x$

$-120\,N = 40\,kg\ a$

$a = -3\ m/s^2$

What is Fred's acceleration after he is out of Mary's reach?

0

What are their final velocities?

$v_f = v_0 + at$

Fred: $(2\ m/s^2)(.5\,s) = 1\ m/s$

Mary: $= (-3\ m/s^2)(.5\,s) = -1.5\ m/s$

Answers: 2 m/s^2, 3 m/s^2, 0, 1 m/s, 1.5 m/s

Ropes

Pulling on a rope creates tension (T) inside of it. This is a force.

You pull on the rope… and it pulls on you

What direction do ropes pull? Always ~~outward~~ inward

If rope is "massless", tension pulling on both ends is: the same

From warmup

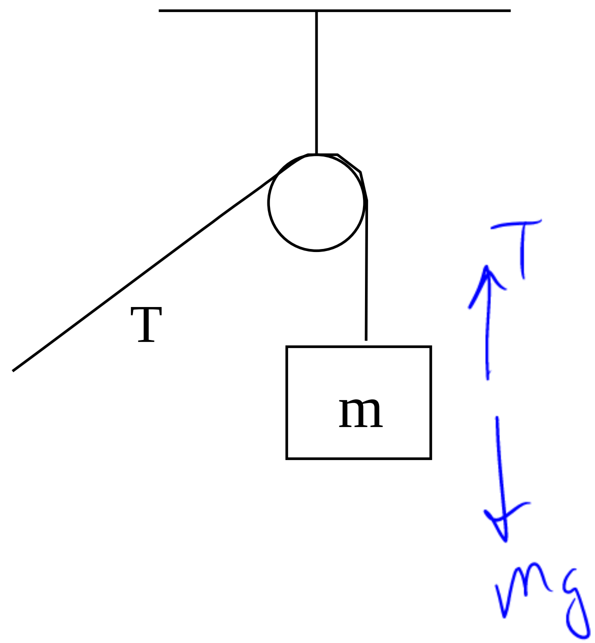
Two teams are having a tug-of-war, using a nylon rope with essentially no mass. Team A (on the left) is winning--both teams are accelerating to the left. What can you say about the tension in the rope?

a. It is higher on the left than on the right.
b. It is higher on the right than on the left.
c. It is constant throughout the rope.

Pulleys

What do pulleys do?

(massless, frictionless)



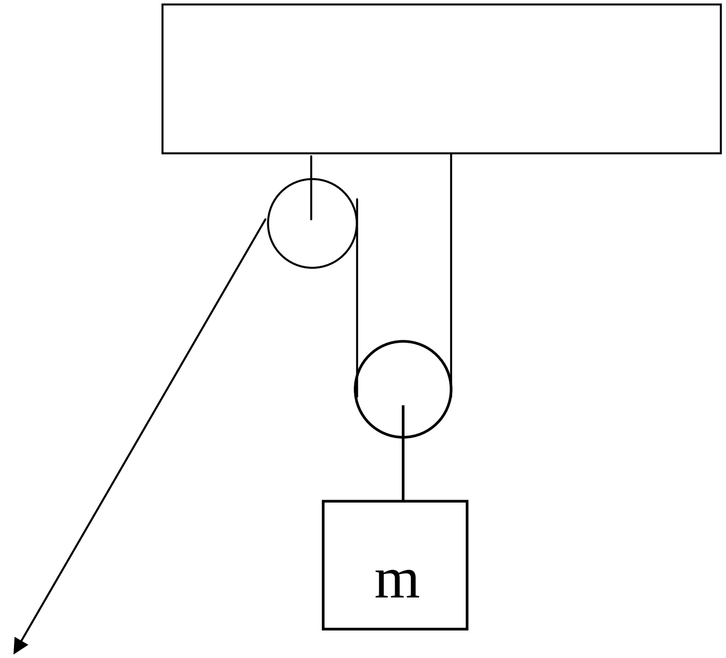
Demo: Basic pulley

Question: Does tension always = weight of object?

No! it could be accelerating

Moveable pulleys

Image credit: wikipedia
(One of six “simple machines”)



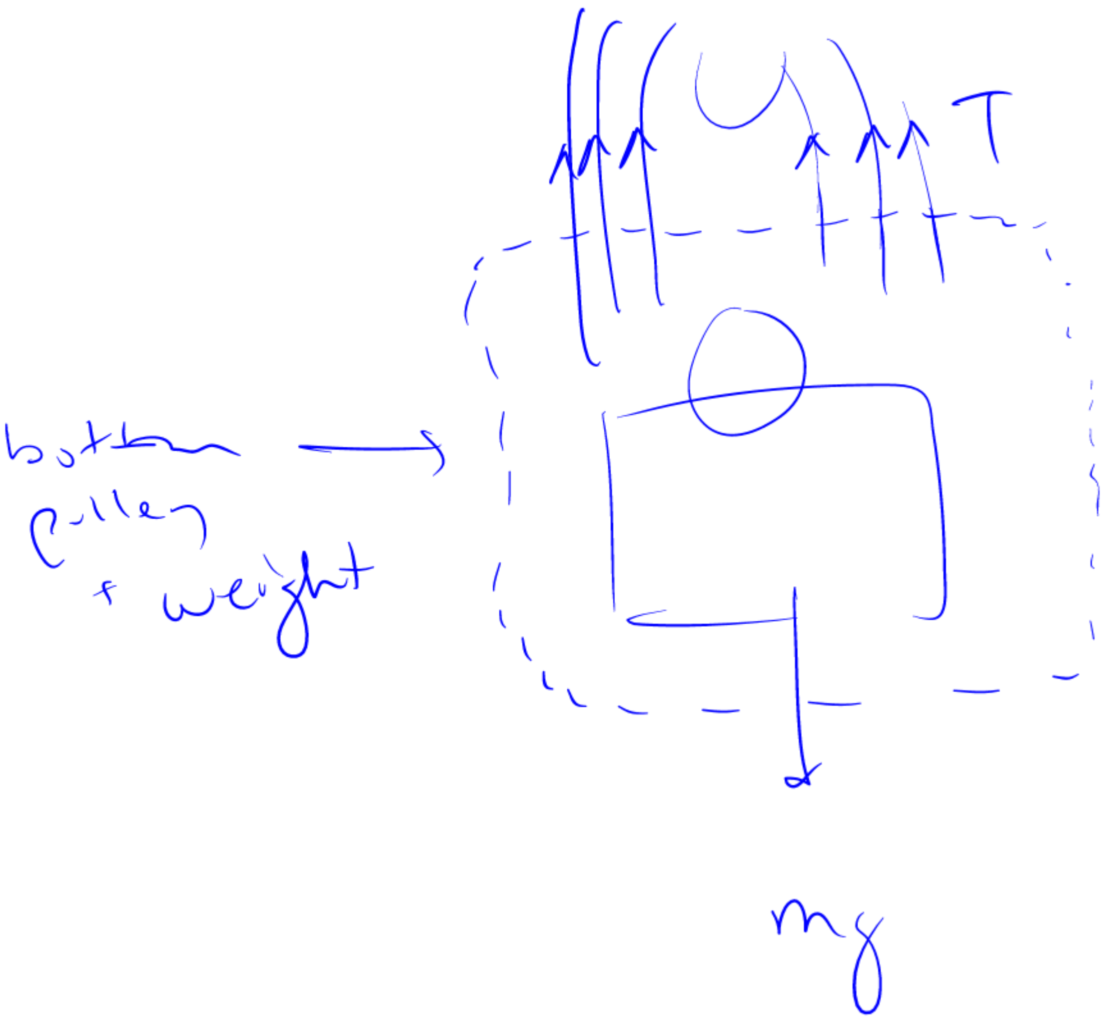
Gives *mechanical advantage*

Tension required to hold or slowly lift is *lower* than lifting the mass directly

Trade off: You have to pull for a **longer distance.**

Demo

Mechanical advantage 8-pulley demo



$$\Sigma F = ma = 0$$

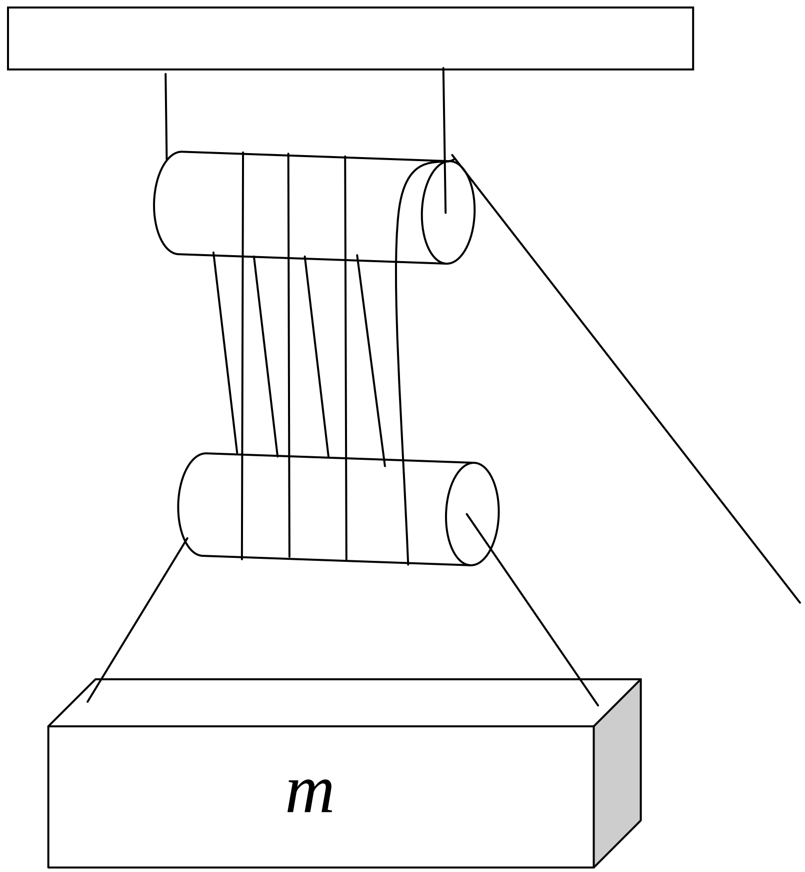
$$6T - mg = 0$$

$$T = \frac{mg}{6}$$

Solving physics problems with moveable pulleys:

- Draw FBD of the moveable pulley and connected masses
- See how many T-vectors are pulling upward
- Solve Newton's 2nd law

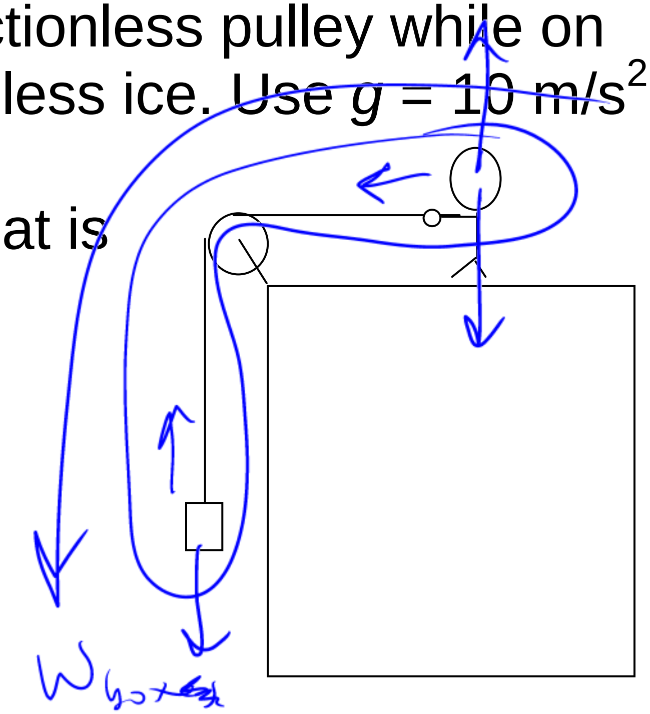
Problem: Assume frictionless, massless string and pulleys, and negligible acceleration. What is the tension in the string you pull?



Worked Problem

Gilbert (100 kg) is lifting the 50 kg box over a frictionless pulley while on top of a building. He then steps on some frictionless ice. Use $g = 10$ m/s^2.

a. Treat Gilbert and the boxes as one group. What is the magnitude of the force (from outside) that accelerates the group?



$$W = m_{box} g = 500\,\text{N}$$

b. What is the acceleration of the group?

$$\sum F_{group} = m_{group} a_{group}$$

$$500\,\text{N} = (150\,\text{kg})\, a$$

$$a = \frac{500}{150} = 3.33\ \text{m/s}^2$$

Answers: 500N, 3.33 m/s^2

c. What is the tension in the rope above the two boxes?

$\sum F = ma$ (↑)

Method 1

Look at Gilbert

$\sum F_G = m_G a_G$

$T = (100\,kg)(3.33\,m/s^2)$

$= 333\,N$

Method 2

Look at box

$T - w = (50\,kg)(-3.33\,m/s^2)$

$T = w_{box} + (50)(-3.33)$

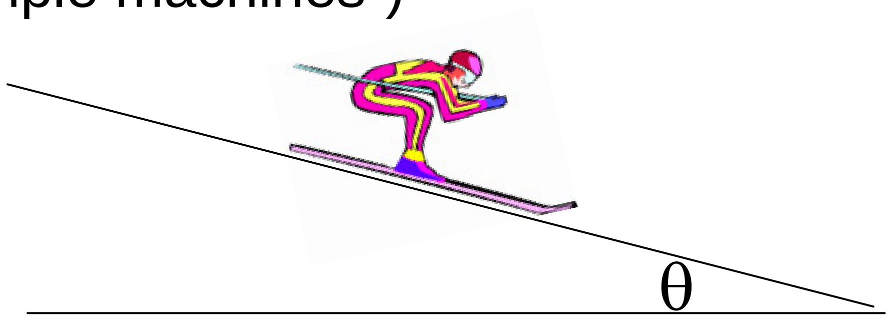
$= (50)(10) + (50)(-3.33)$

$= 333\,N$

Answer: 333 N

Inclined planes!

(another of the "simple machines")



From warmup: A skier is on a hill with no friction and a 20° slope. What is her acceleration?

a. Less than 9.8 m/s^2
b. Equal to 9.8 m/s^2
c. More than 9.8 m/s^2

Question

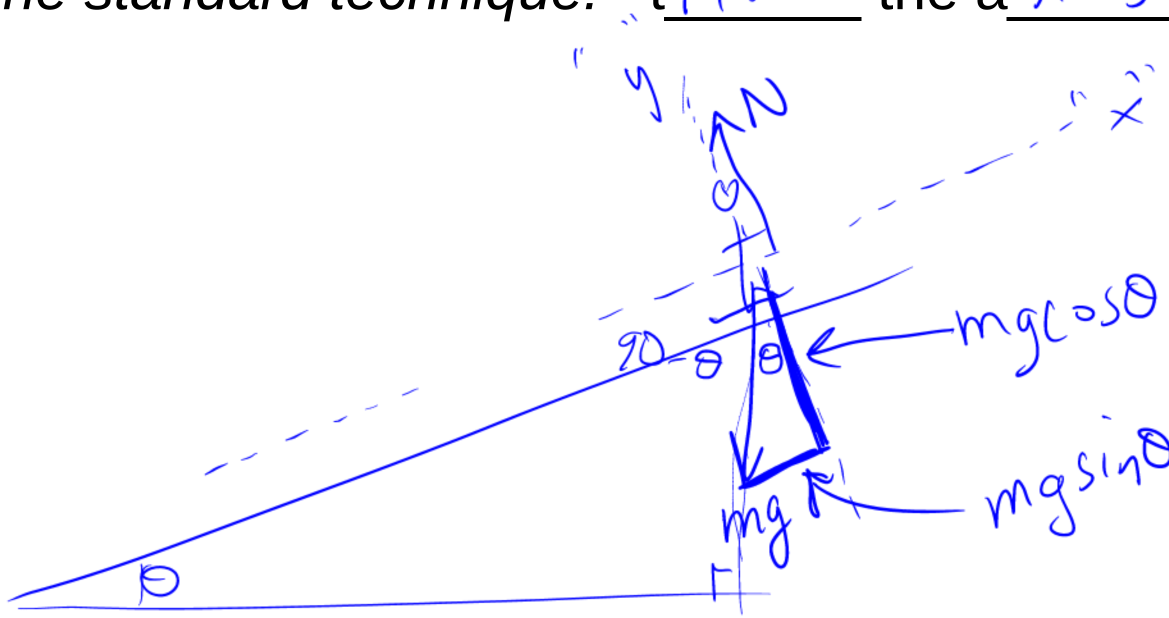
What is her *precise* acceleration? (if no friction, no other forces)

Hint: think of her acceleration for two extremes:

level ground → 0 ✓

infinite slope → 9.8 m/s² ✓

The standard technique: t<u>ilt</u> the a<u>xes</u>



$\Sigma F_{\text{"y"}} = 0$

$N - mg\cos\theta = 0$

$N = mg\cos\theta$

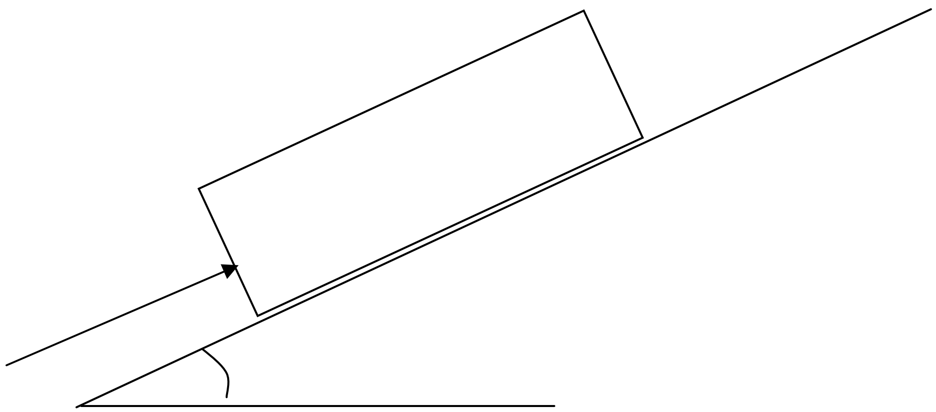
$\Sigma F_{\text{"x"}} = ma_{\text{"x"}}$

$mg\sin\theta = ma_x$

$g\sin\theta$

Worked Problem

You push with a force of 200 N on a 25 kg frictionless ice block which is on a hill sloping 30° above the horizontal. What is the acceleration of the block? Use $g = 10\ m/s^2$.



Answer: $3.0\ m/s^2$