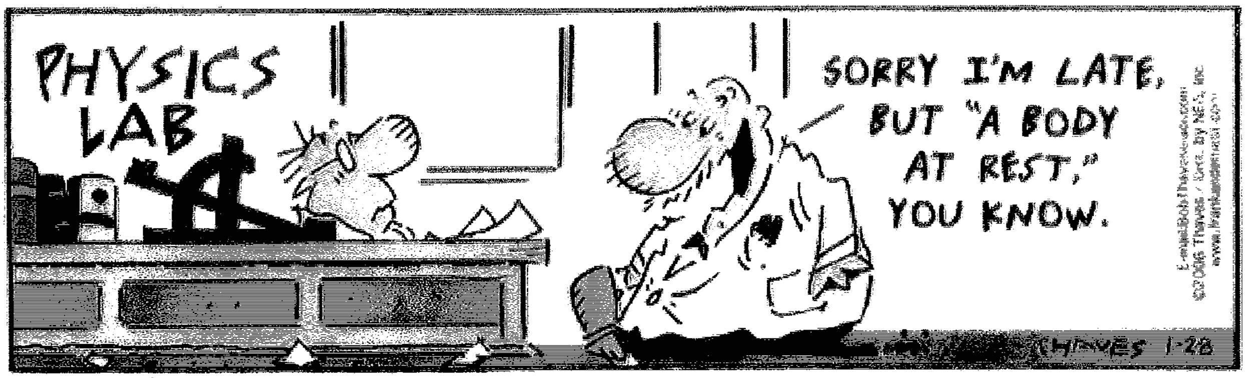
Announcements – 17 Sep 2009

Recall
A = 93%
A- = 89%
B+ = 85%
B = 81%
B- = 77%
C+ = 73%
C = 65%
C- = 58%
D+ = 54%
D = 49%
D- = 45%

1. **Exam 1 results**
   a. Scores:
      i. 75th percentile = 88%
      ii. 50th percentile (median) = 77%
      iii. 25th percentile = 64%
   b. You will get back the exam soon (Friday? 3pm)--pick up your exams in the "turn back" boxes (open boxes at the top), near N357 ESC, sorted by first two numbers of CID
   c. Solutions will be posted on website soon (~~Monday?~~) Friday 3pm
2. **If you have questions** on the exam:
   a. Look over your own exam.
   b. Look over the posted solutions, see if you can figure out why you got the problems wrong.
   c. If you can't figure things out on your own, you can come talk to me (or TAs)
3. **HW 5** (due next Wed) will require free body diagrams to be turned in for some problems. **Use forms at end of HW.**
   a. Read the "Free Body Diagrams" page in the syllabus.
   b. Turn them in to the "turn in" boxes near N357 ESC (closed boxes on bottom left)
   c. They'll be returned to the "turn back" boxes
   d. If you can't get to campus: Sara (the grader) said it would be OK for you to scan & email her your FBDs.
      i. Due at the same time (11:59 pm)
      ii. Don't expect to get as much feedback
4. I'll be out of town tomorrow (Fri)—**no office hours**.

Newton's First Law at work!

Frank & Ernest



Which part of today's assignment was particularly hard or confusing?

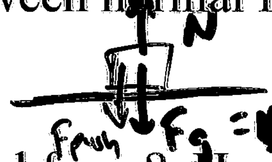
$\xleftarrow{F_1}$ ——— $\xrightarrow{F_2}$

I know that if you have two teams doing tug of war and neither are moving then the F is zero, but what if they are moving in one of the directions.

If const vel, $a = 0 \Rightarrow F_{net} = 0$

$F_1 = F_2$

What is the difference between normal force, n, and the reaction force of gravity, -Fg' ?



the earth pulling down

$F_g =$ [redacted] on box → field force

I'm still confused on normal force? How does that work when an item is falling? What is an item pushing on if it is falling and gravity is pulling it down?

$\Sigma F = ma$

$N - F_{push} - F_g = 0$

$N = F_g + F_{push}$

General comments:

My 8-year-old cousin asked me this question and I didn't know how to answer it: If you throw a boomerang in outer space, will it come back?

Will we be able to look over the exams to see what we did wrong?

Is the answer key of the exam going to be on the web?

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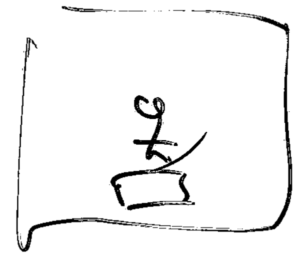
Elevators (from last time)



Worked Problem: 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?

$\Sigma F = ma$

$N - mg = 0$

$N = mg = 392\,N$

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

$N = 312\,N$

$\Sigma F = ma$

$N - mg = ma$

$N - 392 = (40)(-2)$

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

$a = 0$

Same as part a!

d. What happens when the elevator begins to stop?

$a = +2\,\frac{m}{s^2}$

$N = 392 + 80\,N$

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

Newton's 1st Law, revisited

"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

only 56% got this right!

Demo: Inertia Card and Ball
Demo: Inertia Hoop and Pen
Demo: Tablecloth jerk
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

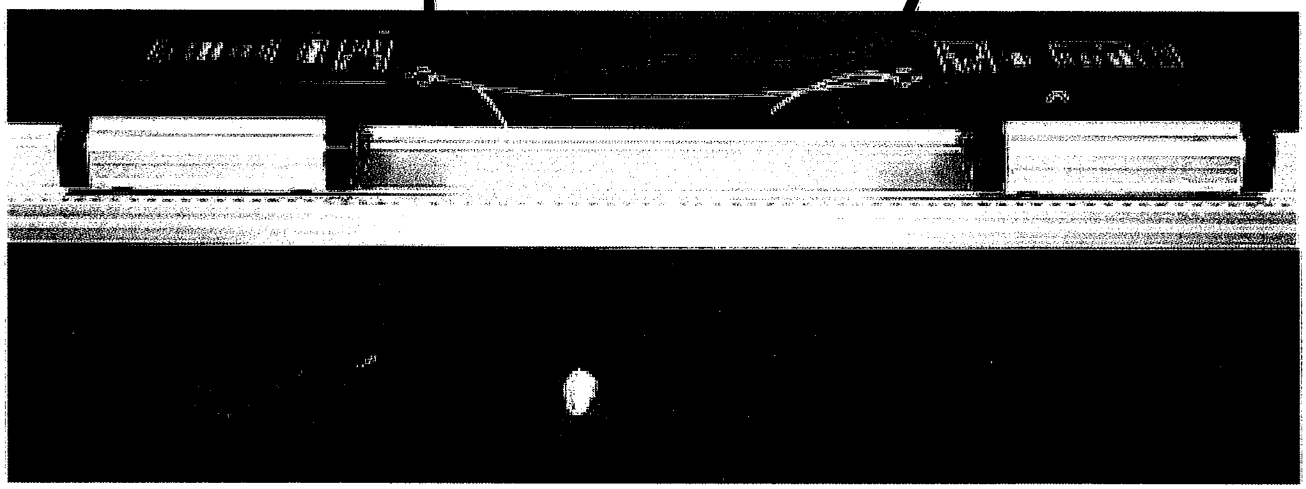
Newton's 3rd Law, revisited

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

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

The demo we didn't do: Force-sensing carts

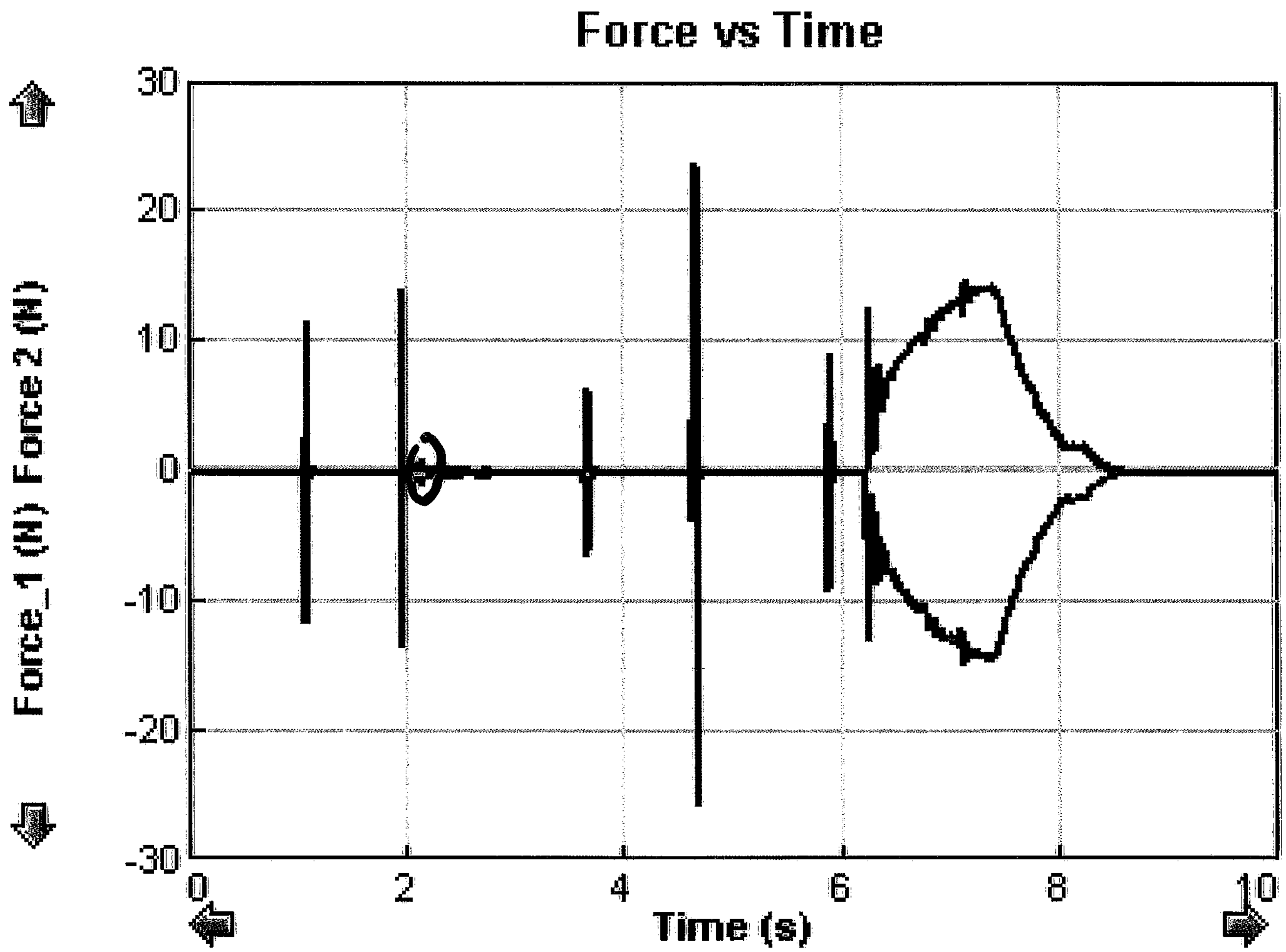
F_1 F_2



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 which direction they are accelerating

http://www.oberlin.edu/physics/catalog/demonstrations/mech/thirdlaw.html



Newton's 2nd Law, revisited

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

Different types of forces:

- Gravity (weight) ✓
- Normal force ✓
- Regular push or pull ✓
- Friction Next time
- Rope (tension) } Now!
- Springs

Later

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? No

Answer from the class:

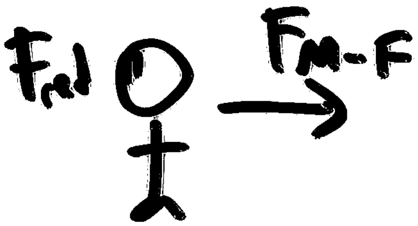
667--------------------------

The force on the penny is greater because it has greater mass. F=ma. The acceleration is the same for both but since the mass is different, the force is also different.

$\to F_{net} = ma$

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?

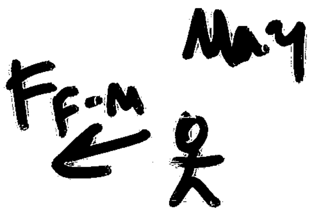


$\Sigma F_{Fred} = m_{Fred}\, a_{Fred}$

$120N = \cancel{60kg}\, a_{Fred}$

$a_{Fred} = 2\ m/s^2$ right

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



$\Sigma F_M = m_M a_M$

$120N = \cancel{40kg}\, a_M$

$a_M = 3\ m/s^2$ left

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

zero

What are their final velocities?

$v_f = v_0 + at$

Fred

$v_f = 0 + (2)(.5)$

$= 1\ m/s$ right

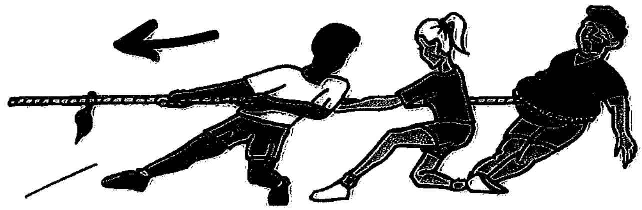
Mary

$v_f = 0 + 3(.5)$

$= 1.5\ m/s$ left

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.

N3

You pull on the rope.... and it pulls on you

What direction do ropes pull? Always inward

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

F_A —— F_B

$$\Sigma F = ma$$

$$T_B - T_A = 0$$

$$T_B = T_A$$

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.

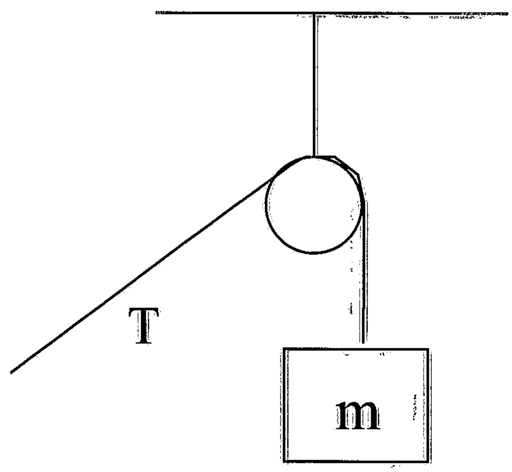
b. It is higher on the right than on the left.

c. It is constant throughout the rope.

Pulleys

What do pulleys do?

(massless, frictionless)



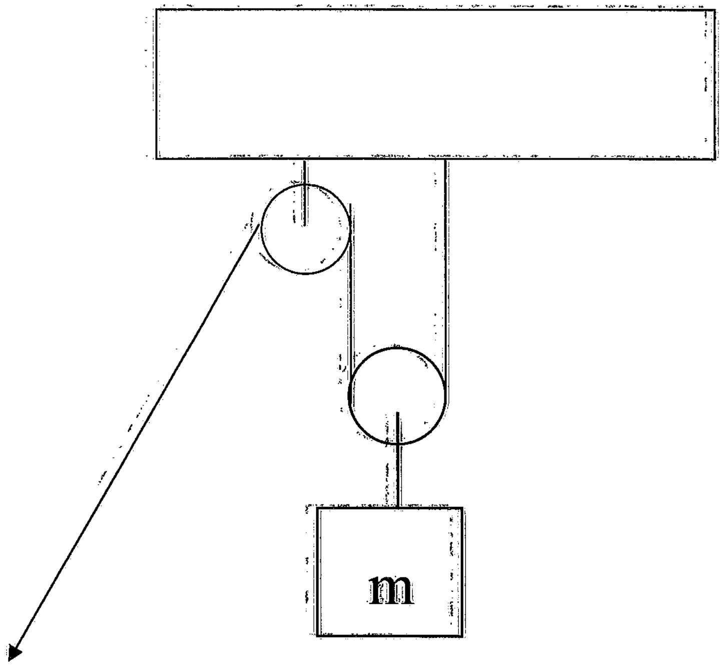
Demo: Basic pulley

Question: Does tension always = weight of object?

Not necessarily!

Moveable pulleys

Image credit: wikipedia



(One of six "simple machines")

block + tackle

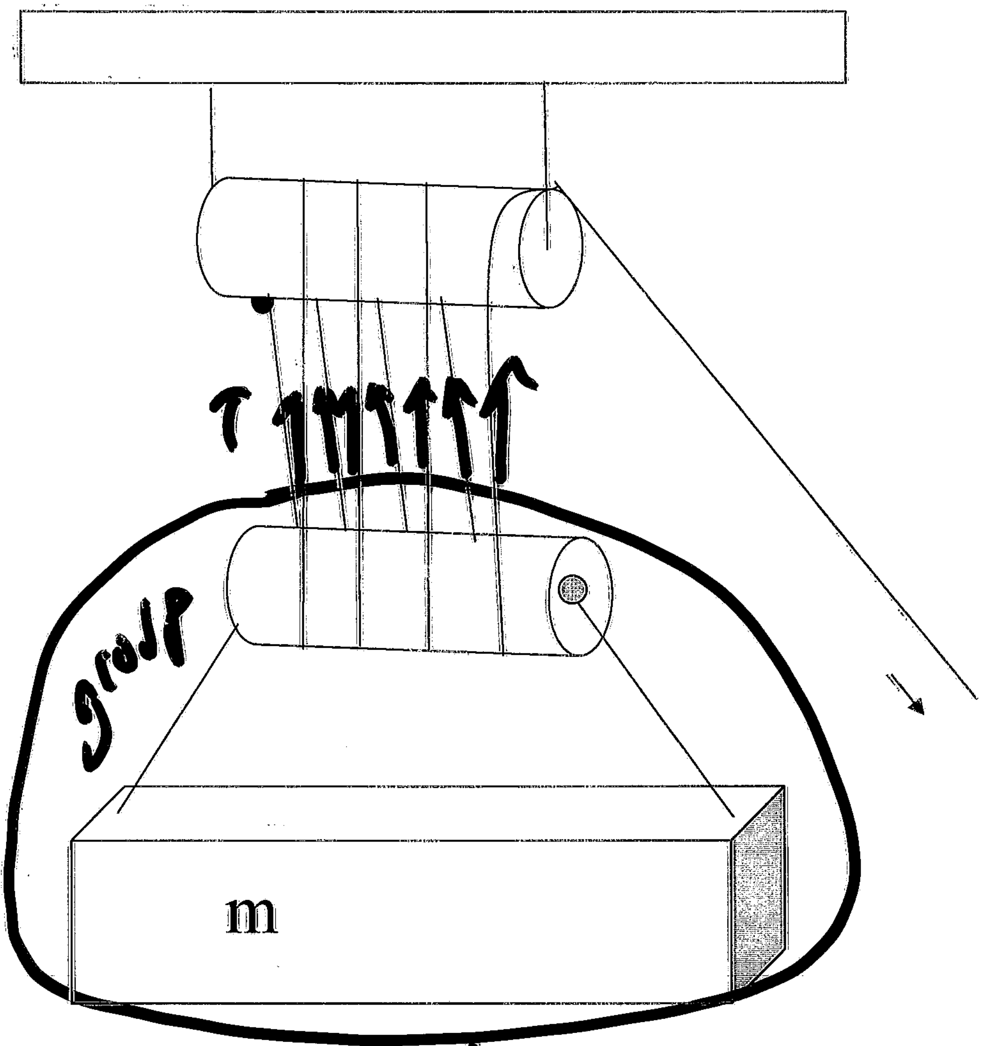
Gives *mechanical advantage*

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

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

<u>Solving physics problems with moveable pulleys:</u>

- 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?

mg

$$\Sigma F = ma$$

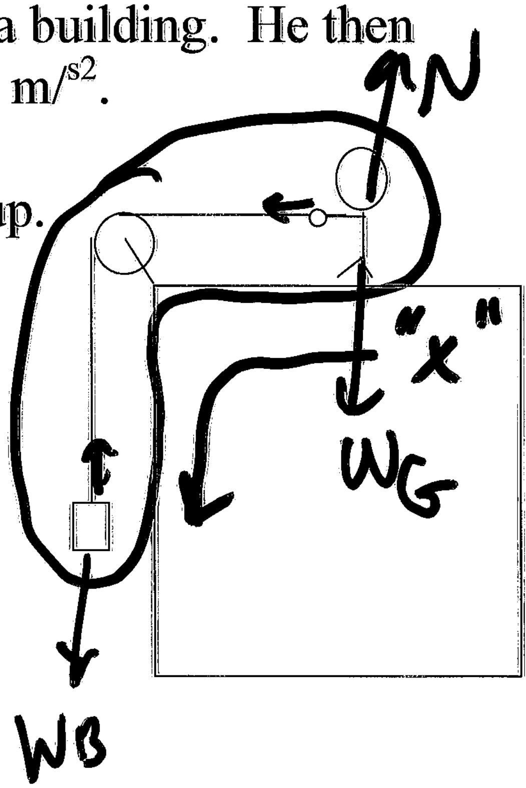
$$T+T+T+T+T+T+T+T-mg = 0$$

$$8T = mg$$

$$T = \frac{1}{8} mg$$

Demo: Mechanical advantage & pulley demo

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?

$m_B g$

$(50)(10) = 500N$

b. What is the acceleration of the group?

$\Sigma F_{x_{group}} = m_{group} a_{group}$

$500N = 150 \text{ kg } a_{group}$

$a_{group} = 3.33 \text{ m/s}^2$

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

Method 1

T

$\Sigma F_{box} = m a_{box}$

$T - m_B g = m(-3.33)$

$m_B g$

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

$T = 333N$

Method 2

N

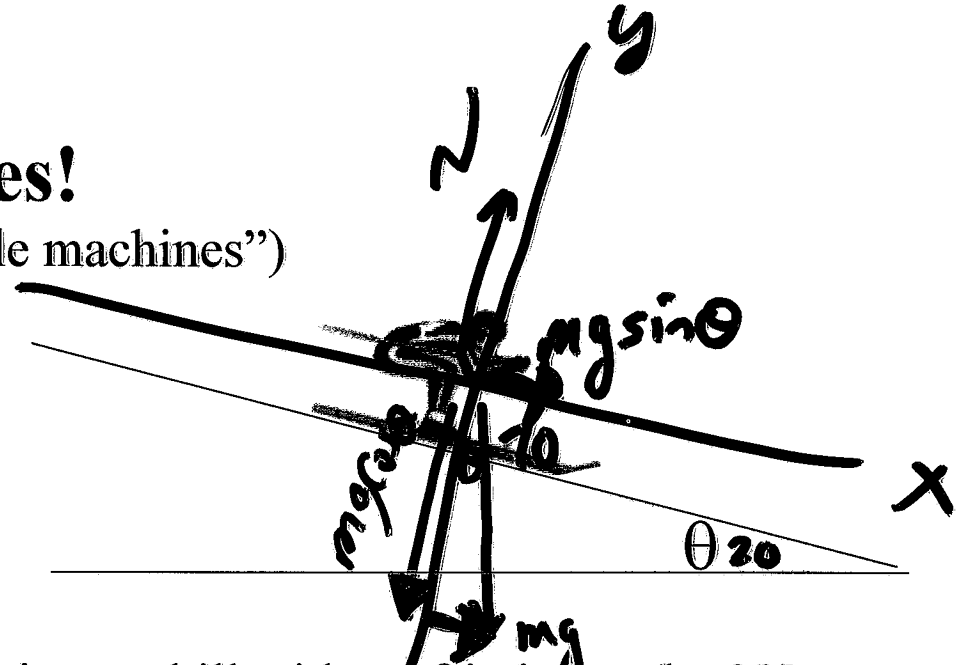
T

$m_G g$

Answers: 500N, 3.33 m/s^2, 333 N

Inclined planes!

(another of the "simple machines")



Clicker quiz: A skier is on a hill with no friction and a 20° slope. What is her acceleration? (same situation as warmup)

a. Less than 9.8 m/s²
b. Equal to 9.8 m/s²
c. More than 9.8 m/s²

only 49% got right

Hint: think of her acceleration for two extremes:

level ground zero

90° infinite slope $9.8\,m/s^2$

What is acceleration for a given angle *θ*?

$$\Sigma F_x = m a_x$$

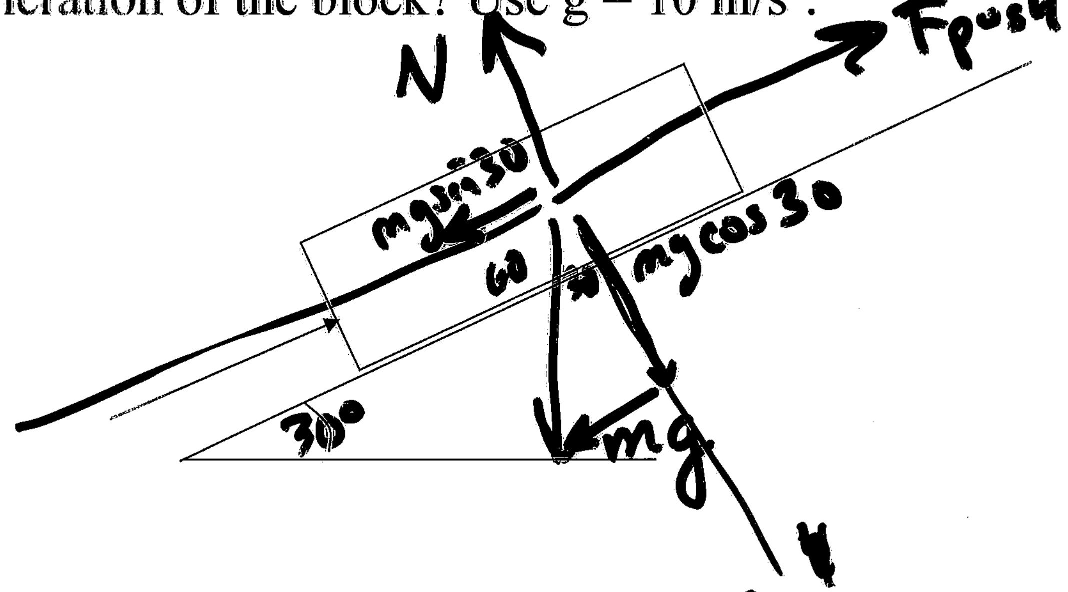
$$\cancel{m} g \sin\theta = \cancel{m} a$$

$$g \sin\theta$$

$$9.8 \sin 20^\circ = 3.35\,m/s^2$$

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.



$$\Sigma F_x = ma_x$$

$$F_{push} - mg\sin 30 = ma$$

$$200 - 25(10)(.5) = (25)a$$

$$200 - 125 = 25a$$

$$75 = 25a$$

$$a = 3\ \text{m/s}^2$$

$$\Sigma F_y = ma_y$$

$$N - mg\cos 30 = 0$$

Answer: 3.0 m/s^2