

PHYS 211

Exam 1 Prep



UNIVERSITY OF
ILLINOIS
URBANA-CHAMPAIGN

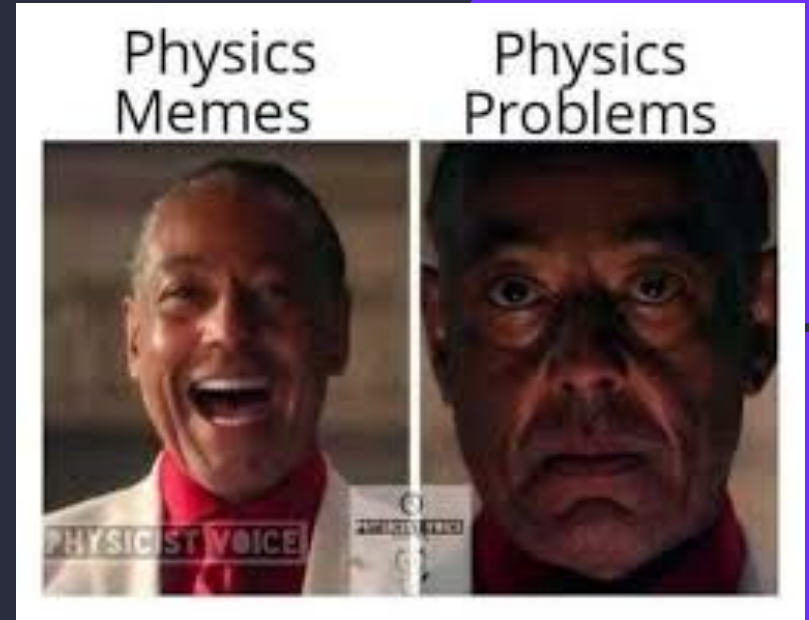


SCAN ME



1. Overview

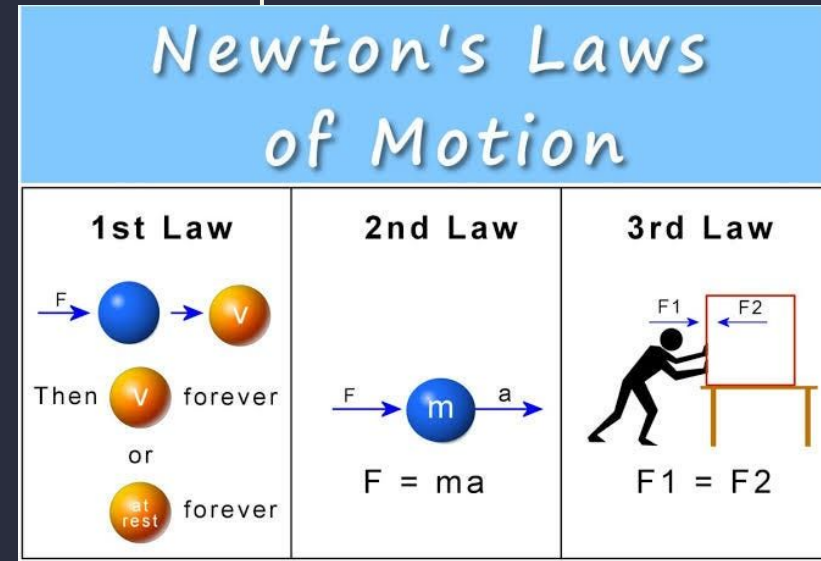
Quick Bits of info to know



Newton's Laws

- **1st Law:** Velocity of an object is constant if the sum of forces on the object is zero,
 $F=0 \Leftrightarrow dv/dt=0 \Leftrightarrow a=0$
- **2nd Law:** The net force on an object is equal to its mass times its acceleration,
 $F=ma$
- **3rd Law:** Any forces acting on an object will have an equal and opposite reaction,
 $F_{a,b} = -F_{b,a}$

*These equations are true for all interactions in Phys 211! Note that the forces and acceleration are vectors; direction matters

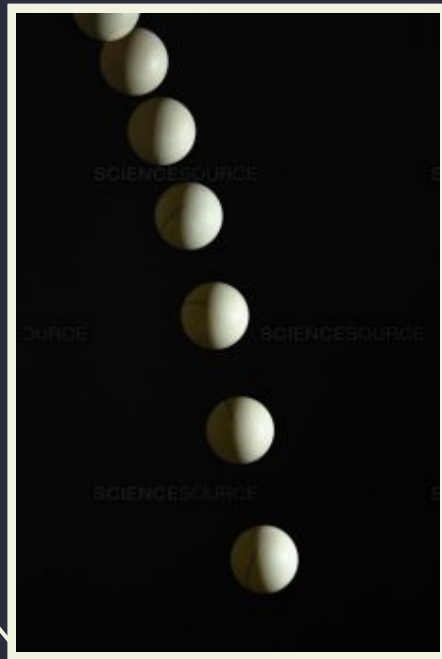




1-D, 2-D Kinematics:

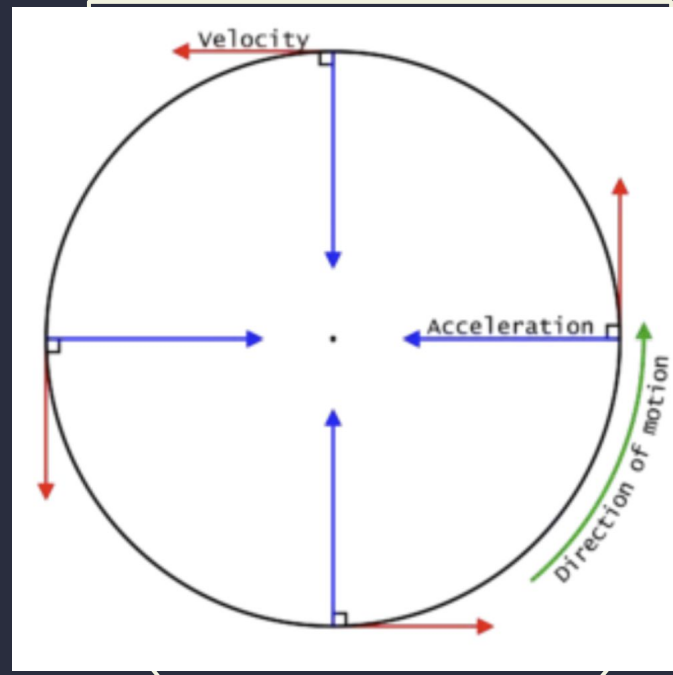
Equations associated with Kinematics:

- | | |
|---|--------------------------|
| 1. $v = v_o + at$ | 1. No x (final position) |
| 2. $r = r_o + v_o t + \frac{1}{2} at^2$ <ul style="list-style-type: none">○ r is the position in x or y | 2. No v (final velocity) |
| 3. $v^2 = v_o^2 + 2a(x - x_o)$ | 3. No t (time) |
| 4. $r - r_o = \frac{1}{2}(v_o + v) t$ <ul style="list-style-type: none">○ (not on equation sheet!!)○ Can be derived from other | 4. No a (acceleration) |



Circular Motion

- **Centripetal force** is a fictitious force, meaning that it is a result of other forces acting on a system to make it go in circular motion
- **Centripetal acceleration**, for circular motion, is always radially inwards and the velocity is tangential to the path



$$a_c = \frac{v^2}{r}$$

Kinematics Assumptions

Projectile Motion:

- X-direction: v is constant; $a=0$
- Y-direction: v at top = 0; $a = g$
- Remember, time is the same in both x and y
- Break up velocity components if needed

Circular Motion

- Acceleration always points inward
- $v = \omega r$ (and is tangential to the path)
- Direction of individual forces can be different in different positions of the circle

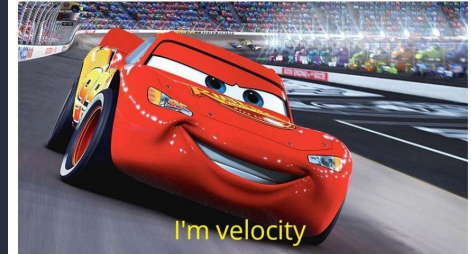
phone is at 1%

me running to get the charger :



phone is at 1%

me running to get the charger
in the north west direction :

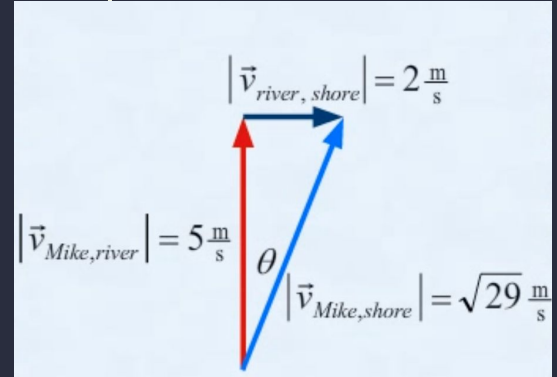


me realizing I also have mass:



Relative Motion

- Explains how an object's velocity can look different depending on how you are observing it
- Reference Frame: A coordinate system from which one system observes another.
 - EX: A boat may move 5 m/s relative to the water, but someone standing on shore sees a different speed because the river current is also moving.



Relative Motion is based in vectors and may involve the use of vector properties.

Think of the bottom words (eg, velocity of A with respect to C):

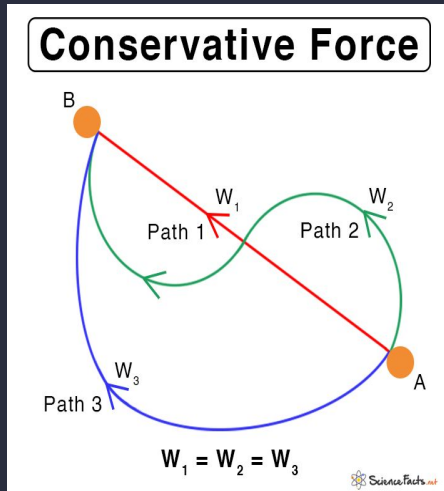
$$V_{A,C} = V_{A,B} + V_{B,C}$$

Forces

Conservative

Path independent!

- **Weight** (Gravity)
- **Spring Force**: $F_s = -k \Delta x$



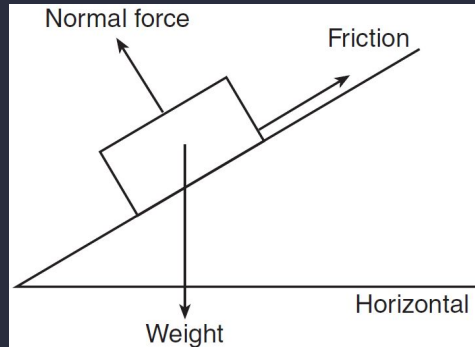
Nonconservative

Path dependent!

- **Normal**:
Perpendicular to an object's surface by below surface
- **Tension**: points away from object
- **Friction**: $f = \mu N$,
opposes motion

Forces

- Force is a vector
 - X and Y components still apply, especially for ramp problems
- Free Body Diagrams:
 - The net force is NOT drawn on the free body diagram
 - Only draw external forces acting on the object



Me: *Applies force to an object*

**Newton's third law of physics:
*Pushes back***



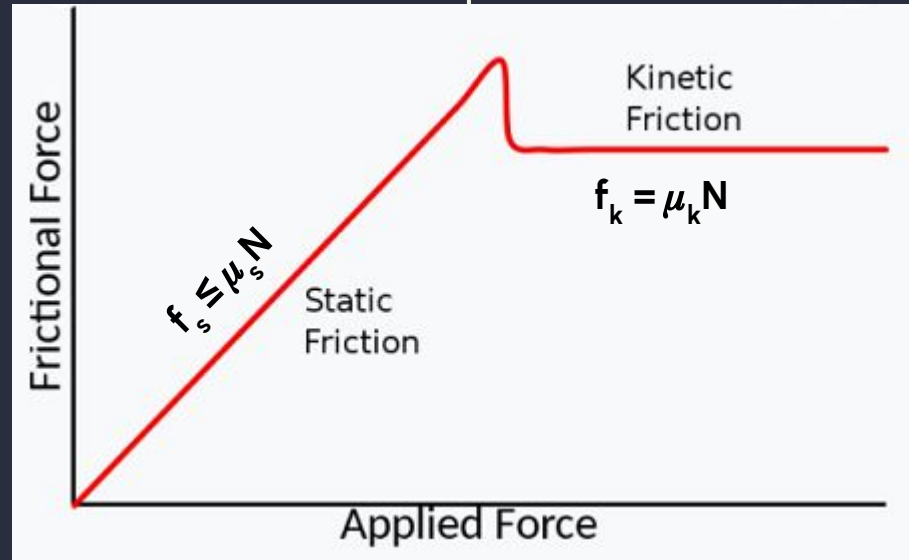
Friction

- Friction is a force that opposes the direction of motion
- Pay attention to which coefficient you are using

Friction

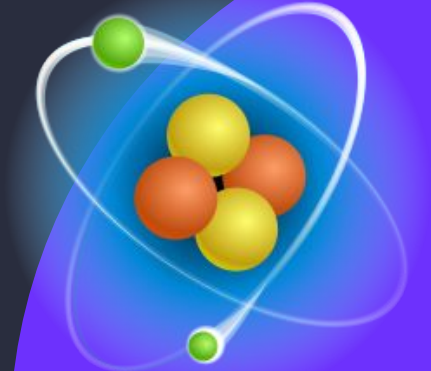
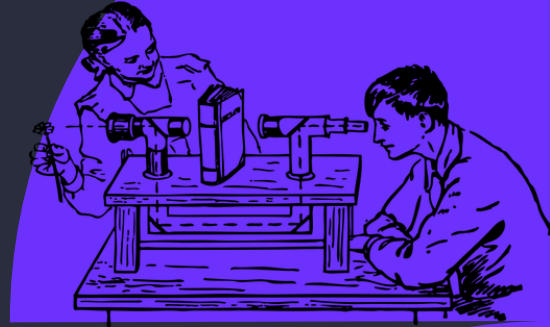
$$f = \mu_k N \text{ (kinetic)}$$

$$f \leq \mu_s N \text{ (static)}$$



2. Problem Solving

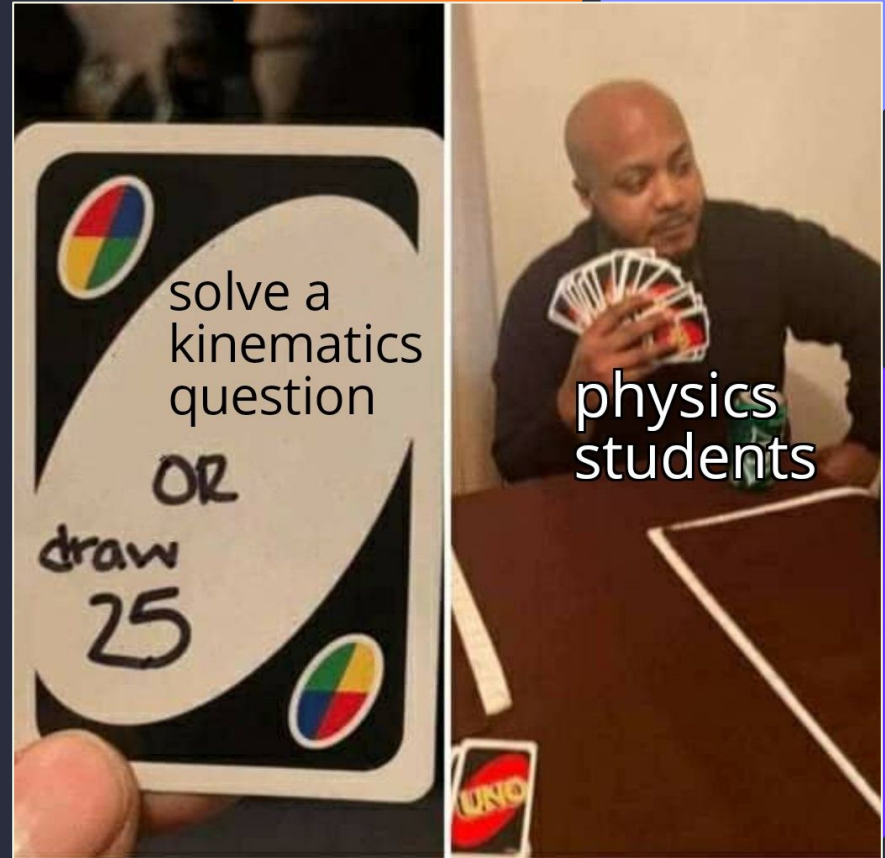
Some Steps to Follow If You Are Lost



Kinematics

How to Identify:

- Projectile Motion
- Given $x/v/a$
- Relative Motion



Kinematics

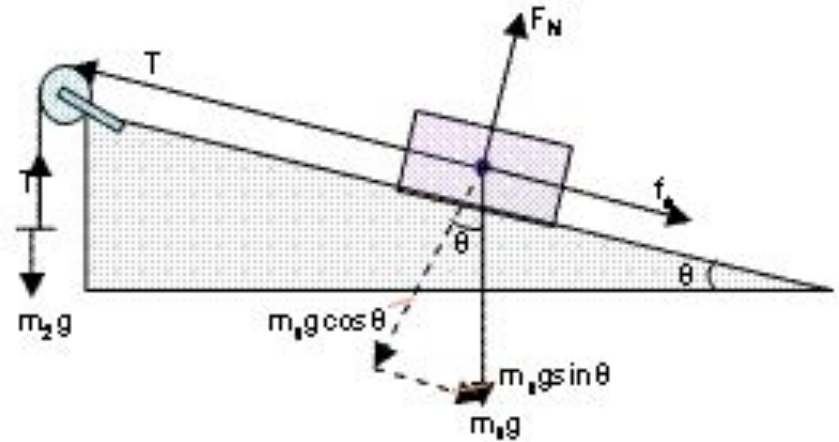
- List given variables
 - In both x and y directions
 - Pay attention to what variables might be 0
- Match up to kinematics equations on equation sheet
 - Look for equations with one unknown variable

$X_0 =$	$Y_0 =$	$V_x = V_{x0} + a_x t$
$X =$	$Y =$	$V_y = V_{y0} + a_y t$
$V_{x0} =$	$V_{y0} =$	$X = X_0 + V_{x0} t + \frac{1}{2} a_x t^2$
$V_x =$	$V_y =$	$Y = Y_0 + V_{y0} t + \frac{1}{2} a_y t^2$
$a_x =$	$a_y =$	$V_x^2 = V_{x0}^2 + 2a_x (x - x_0)$
$t =$		$V_y^2 = V_{y0}^2 + 2a_y (y - y_0)$

Forces

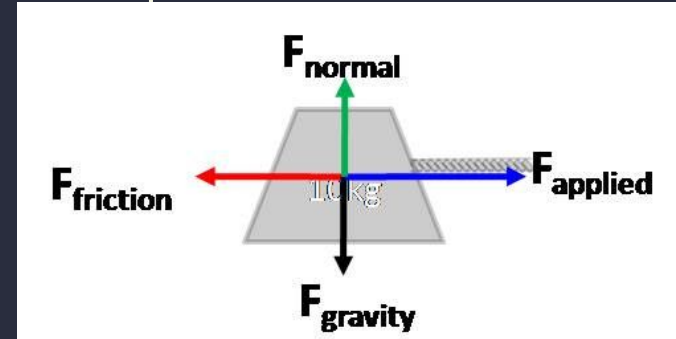
How to Identify:

- Springs
- Mass Slidings
- Ramps
- Strings

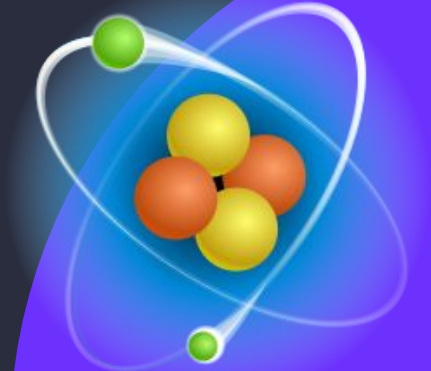
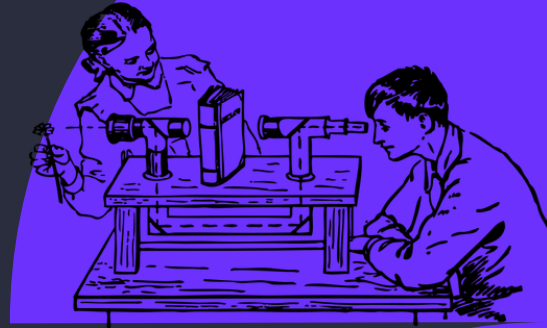


Forces

- ▷ ALWAYS start with Free Body Diagrams
- ▷ Think about Newton's 3rd law reaction pairs!
($F_{a,b} = -F_{b,a}$)
- ▷ Write $F=ma$ equations
 - ▶ In both x and y directions
 - ▶ Pay close attention to the SIGNS of your variables!
- ▷ Solve for the unknown variable(s) in the problem



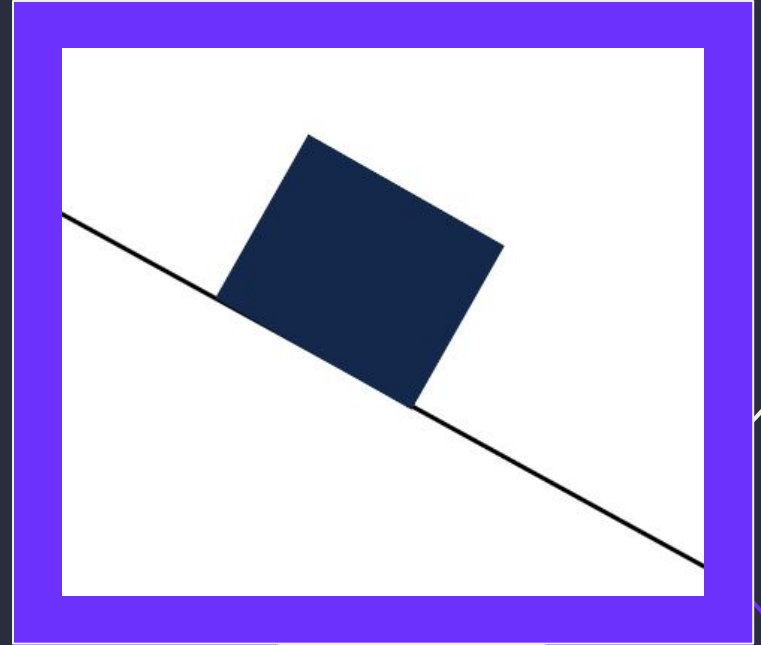
3. Practice Problems



Box on a slanted ramp

Which direction does the normal force point?

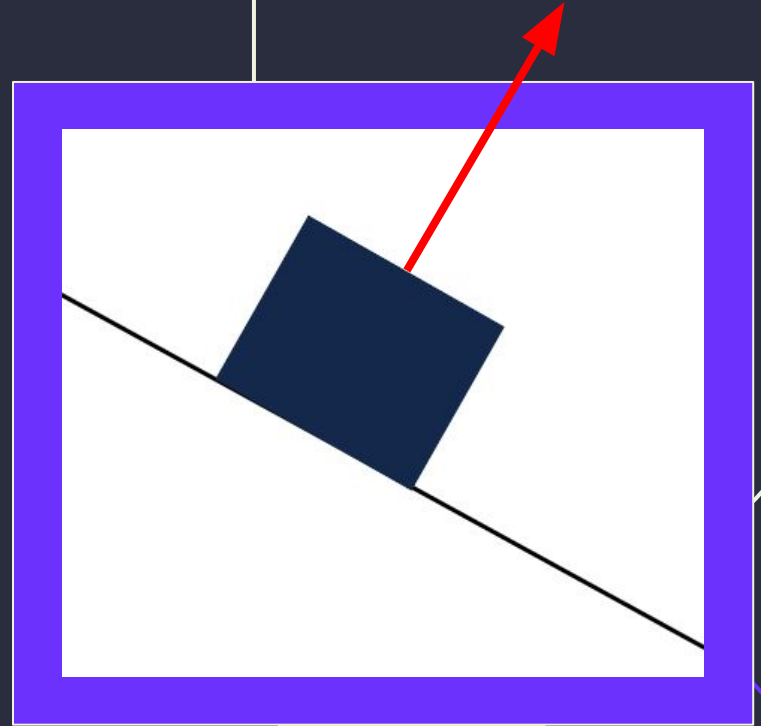
1. Straight up
2. Up and right
3. Straight down
4. Down and right



Box on a slanted ramp

Which direction does the normal force point?

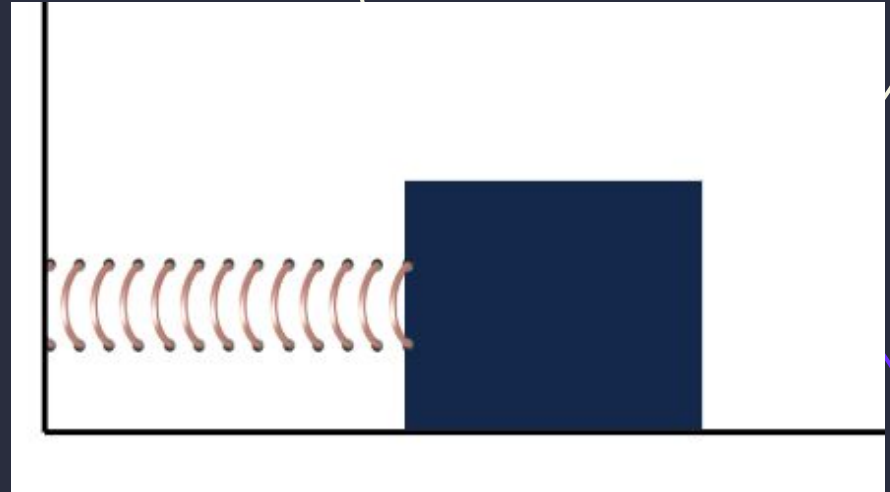
1. Straight up
2. Up and right
3. Straight down
4. Down and right



Box on a spring in compression

Which direction does the spring force point on the box?

1. Up
2. Down
3. Left
4. Right



Box on a spring in compression

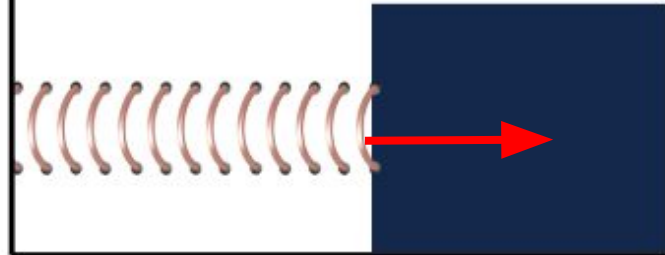
Which direction does the spring force point on the box?

1. Up
2. Down
3. Left
4. Right

Hooke's Law

$$F = -kx$$

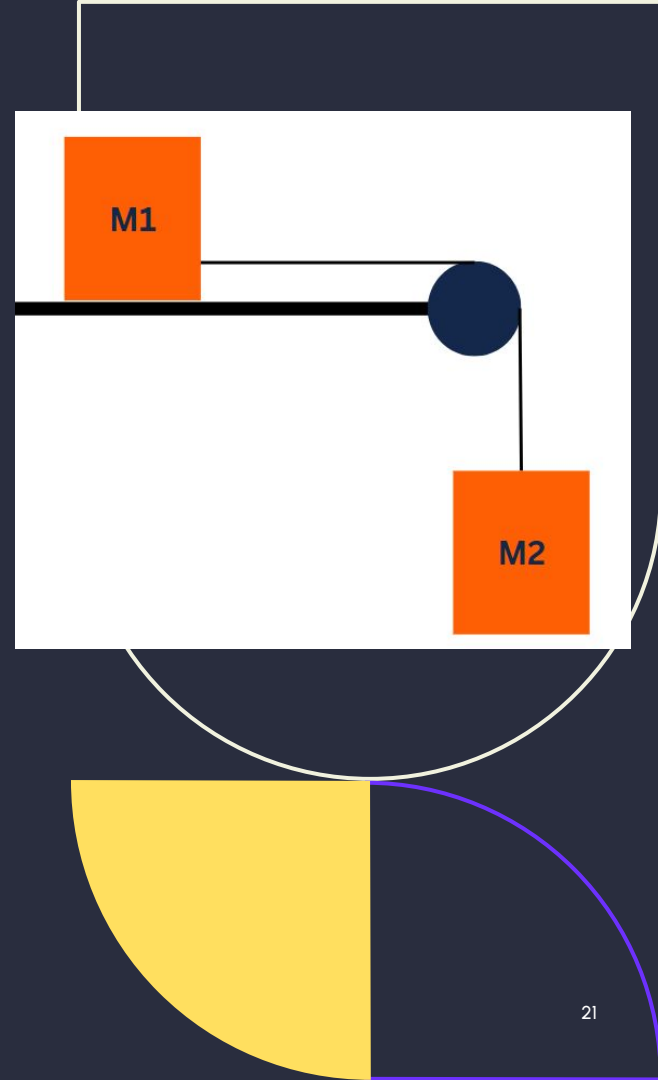
The negative symbol indicates that the force of the spring constant is in the opposite direction of the force applied to the spring



Two boxes connected with a rope

Which direction does the tension force point on M2?

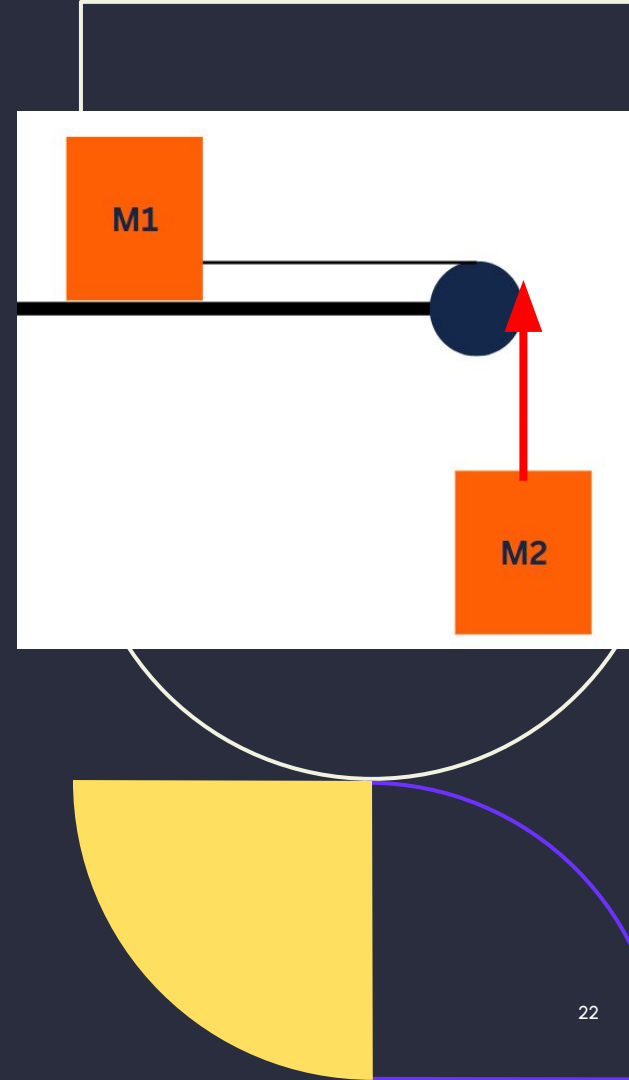
1. Up
2. Down
3. Left
4. Right



Two boxes connected with a rope

Which direction does the tension force point on M2?

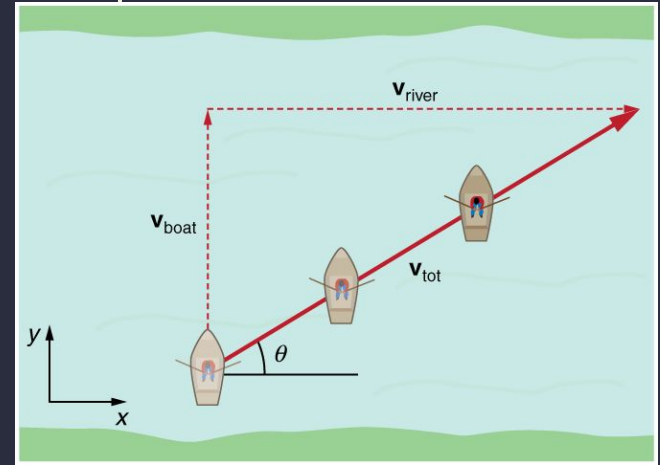
1. Up
2. Down
3. Left
4. Right



Boat Problem

A motorboat points its bow straight across a wide river (perpendicular to the banks) and runs its engine at full speed. A strong current carries the boat downstream as it crosses. If the river current suddenly doubles in speed, what happens to the time it takes for the boat to reach the opposite bank?

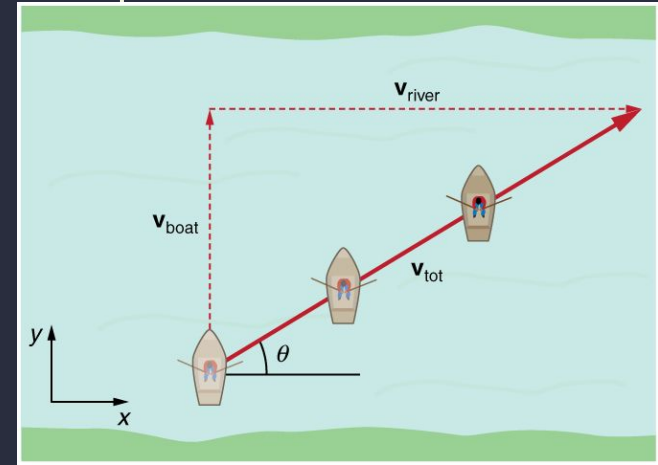
- A) The crossing time doubles
- B) The crossing time increases slightly
- C) The crossing time stays exactly the same
- D) The crossing time decreases



Boat Problem

A motorboat points its bow straight across a wide river (perpendicular to the banks) and runs its engine at full speed. A strong current carries the boat downstream as it crosses. If the river current suddenly doubles in speed, what happens to the time it takes for the boat to reach the opposite bank?

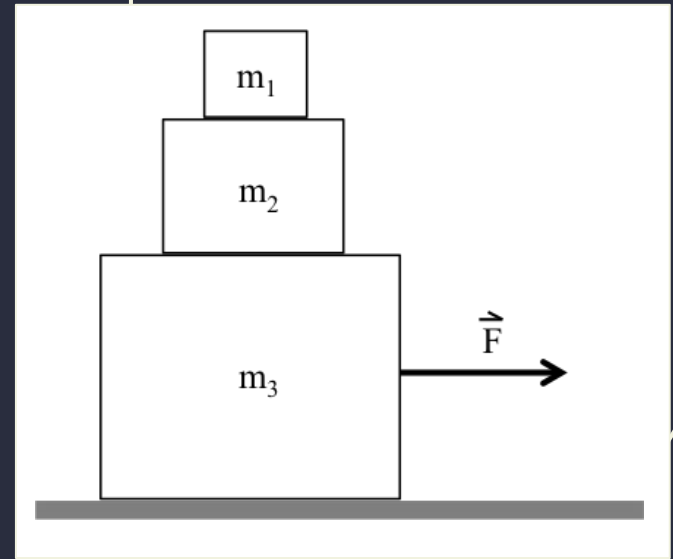
- A) The crossing time doubles
- B) The crossing time increases slightly
- C) The crossing time stays exactly the same
- D) The crossing time decreases



Stack of Boxes (1)

Which direction does friction from m_3 point for the bottom of m_2 ?

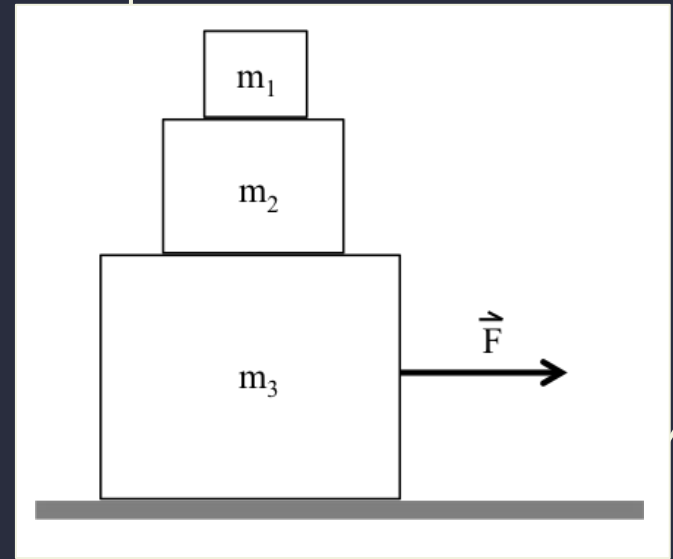
1. Up
2. Down
3. Left
4. Right



Stack of Boxes (1)

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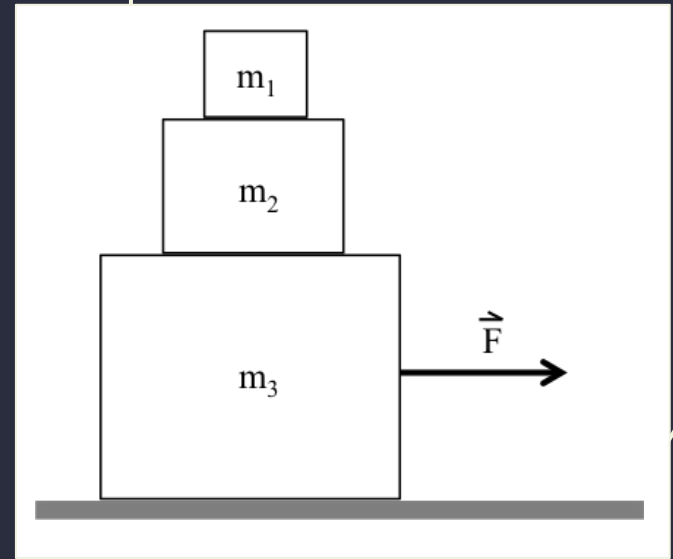
1. Up
2. Down
3. Left
4. Right



Stack of Boxes (2)

Which direction does friction from m_1 point for the top of m_2 ?

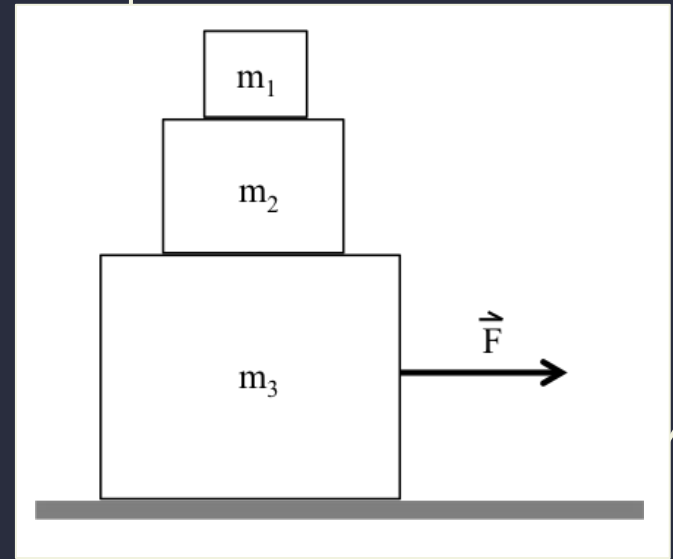
1. Up
2. Down
3. Left
4. Right



Stack of Boxes (2)

Which direction does friction from m_1 point for the top of m_2 ?

1. Up
2. Down
3. Left
4. Right





Worksheet Time!

Enter Queue with your name and net ID:
By entering the queue, you help us:

- Reserve a big enough space at the next review session
- Assign enough tutors for everyone to have access to help

Thank you!

