Physics 121 Review
Midterm Exam # 1

Exam # 1:

Tuesday February 17, 2026
8.00 am – 9.20 am
Hubble Auditorium

Physics 121.
Topics for today.

- A quick covering some of the concepts that are important for Exam # 1.
- How to survive Phy 121 exams?
- Review of the material covered on Exam # 1.
  - Chapter 1: Units
  - Chapter 2: One dimensional motion
  - Chapter 3: Two dimensional motion
  - Chapter 4: Newton's law of motion
  - Chapter 5: Friction forces, drag forces
- **Note: no error analysis on any exam for Phy 121.**

Surviving Phy 121 Exams.

- Time your work:
  - Exam has 10 MC + 3 analytical questions.
  - Work 15 minutes on the MC questions.
  - Work 15 minutes on each of the analytical questions (45 minutes total).
  - You now have 20 minutes left to finish those questions you did not finish in the first 15 minutes.
- Write neatly – you cannot earn credit if we cannot read what you wrote!
- Write enough so that we can see your line of thought – you cannot earn credit for what you are thinking!

Surviving Phy 121 Exams.

- Most solutions should start with a diagram, showing all forces (direction and approximate magnitude) and dimensions. All forces and dimensions should be labeled with the variables that will be used in your solution. You also need to define the coordinate system you will be using,
- Indicate what variables are known and what variables are unknown.
- Indicate which variable(s) needs to be determined.
- Indicate the principle(s) that you use to solve the problem.
- If you make any approximations, indicate them.
- Check your units!

Preparing for Exam # 1

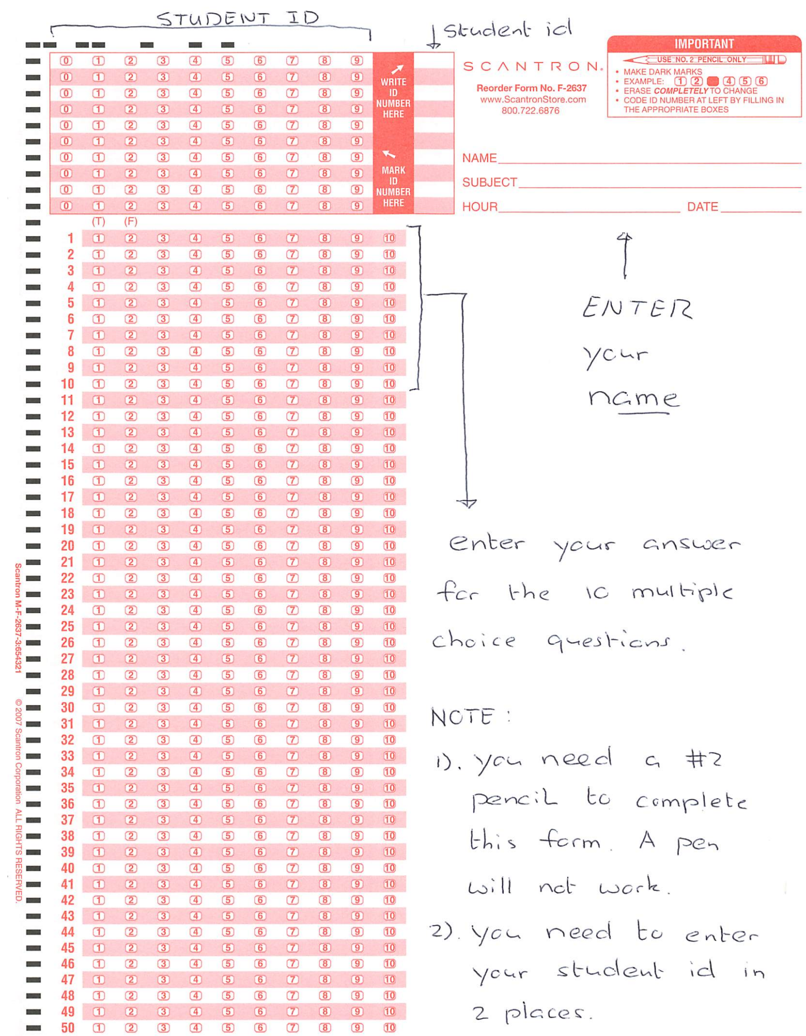
- Take the practice exam as if it was a real exam: take 80 minutes to complete it. Compare your work to the posted solutions to help you focus on specific areas.

- There will be extra office hours on Sunday 2/15 and Monday 2/16:
  - Addison Price: 5 - 7 pm, 2/15, POA
  - Thomas Qian: 7 - 9 pm, 2/15, POA
  - Justin Kenneally: 10 am - 12 pm, 2/16, POA
  - Catherine Lei: 12.30 pm - 2.30 pm, 2/16, POA

- The workshops on Monday 2/16 should be considered Q&A sessions for Exam # 1. Anyone can attend any of the workshops on Monday 2/16.

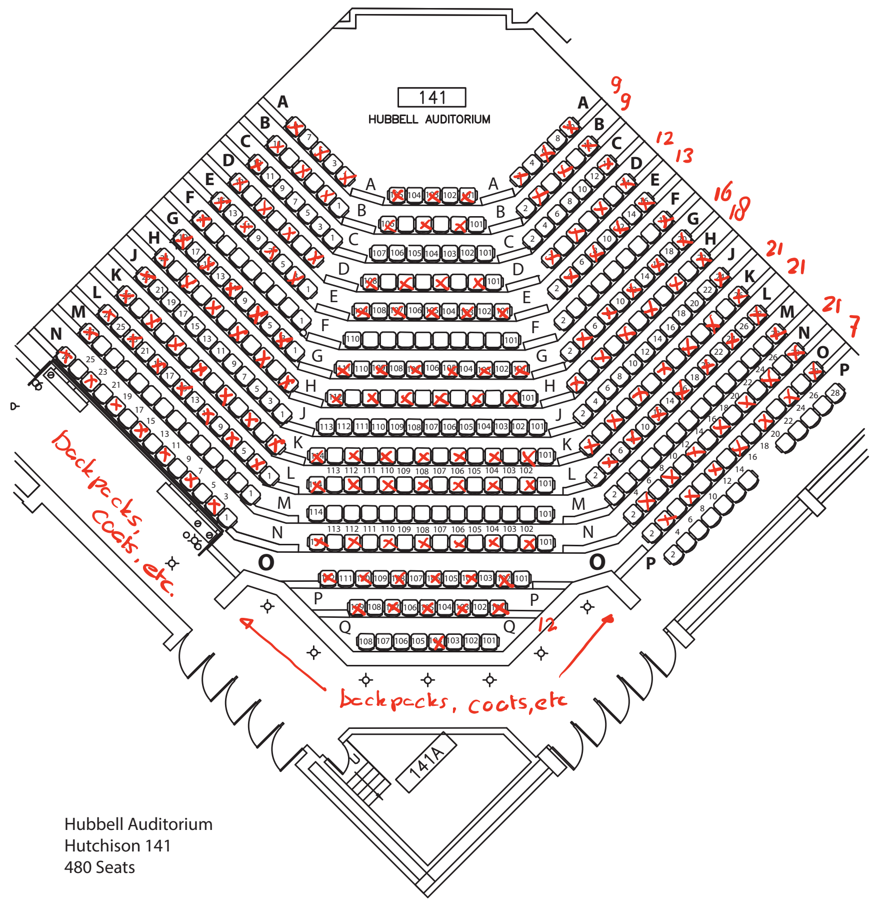
Preparing for Exam # 1

- You need a number 2 pencil to complete the multiple-choice part of the exam.
- You need to know your student ID #.
- You do NOT need a calculator on the exam.
- The exam starts at 8 am and ends at 9.20 am.
- If you are late to start, you will have less time to finish.
- No one can leave before 8.45 am. No one can start after 8.45 am.



Exam Location: Hubbell.

- You can not enter Hubbel before 7.45 am. You can only sit at locations where there is a brown envelope located. Your backpack, coat, and books need to be left at the entrance of Hubbel.
- You will only need your pen, a number 2 pencil, and an eraser. Being awake might also help!



Warning.

- I cannot cover everything I discussed in lectures 1 – 6 in this review.
- If I skip over certain topics, it does not mean you should not understand that material.
- Your TAs will not see the exam until you see it.
- **There will be lecture at 12.30 pm on Tuesday 2/17.**

Review Physics 121
Midterm Exam # 1

- Main topics covered:
  - Motion in one, two, and three dimensions:
    - Definitions of position, velocity, and acceleration.
    - Motion with constant acceleration
    - Projectile motion
    - Circular motion
  - The force laws:
    - Newton’s laws
    - Static and kinetic friction force
    - Drag forces

Describing Motion

- When we limit ourselves to pure translational motion, we in general can describe the any motion in terms of three parameters:
  - The position $x(t)$, $y(t)$, $z(t)$: units m.
  - The velocity $v_x(t)$, $v_y(t)$, $v_z(t)$: units m/s.
  - The acceleration $a_x(t)$, $a_y(t)$, $a_z(t)$: units m/s^2.
- In order to define the motion of an object, we need to select a coordinate system. Different observers will make different observations for the same motion if they use different coordinate systems for their observations.

Defining Motion in One, Two and Three Dimensions.

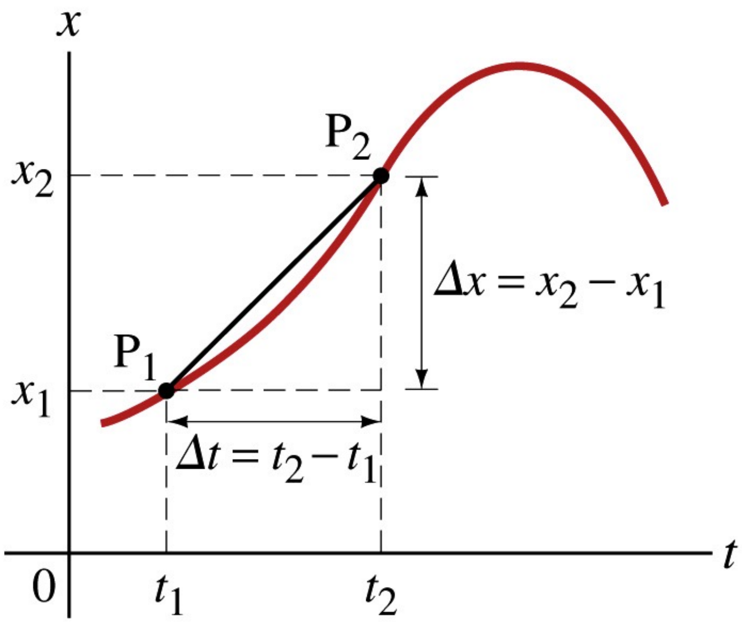
One Dimension

- Position x.
- Displacement Δx.
- Velocity: displacement per unit time. Sign is equal to the sign of the displacement Δx.
- Acceleration: change in velocity per unit time. Sign is equal to the sign of the velocity difference Δv.

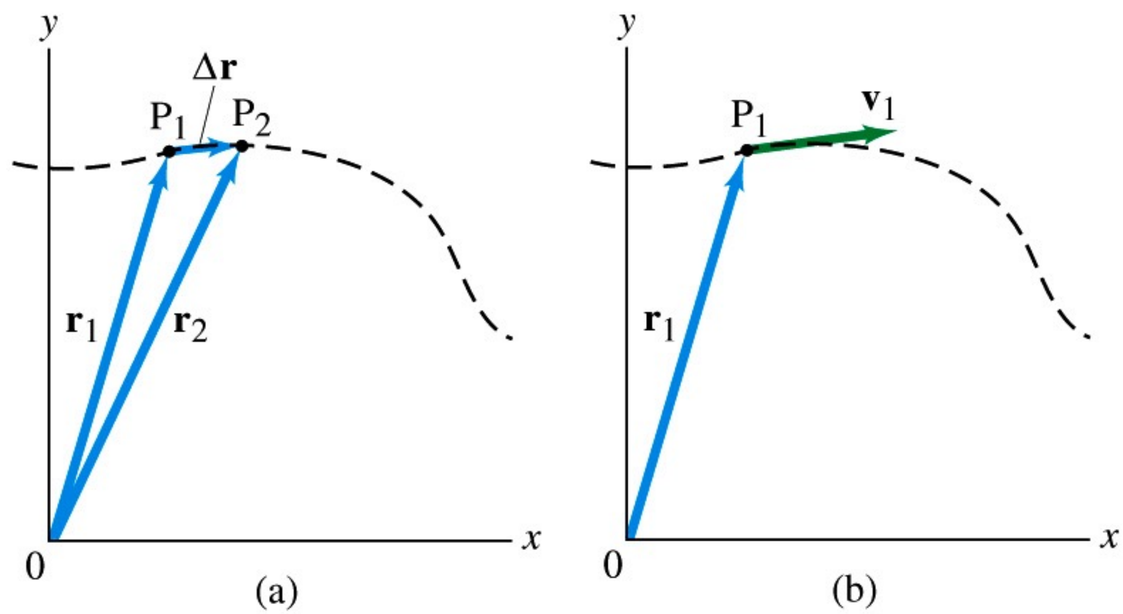
Two/Three Dimensions

- Position vector $\vec{\boldsymbol{r}}$.
- Displacement vector $\Delta\vec{r}$.
- Velocity vector: change in the position vector per unit time. The direction is equal to the direction of the displacement vector $\Delta\vec{r}$.
- Acceleration vector: change in the velocity vector per unit time. The direction is equal to the direction of the velocity difference vector $\Delta\vec{v}$.

Velocity

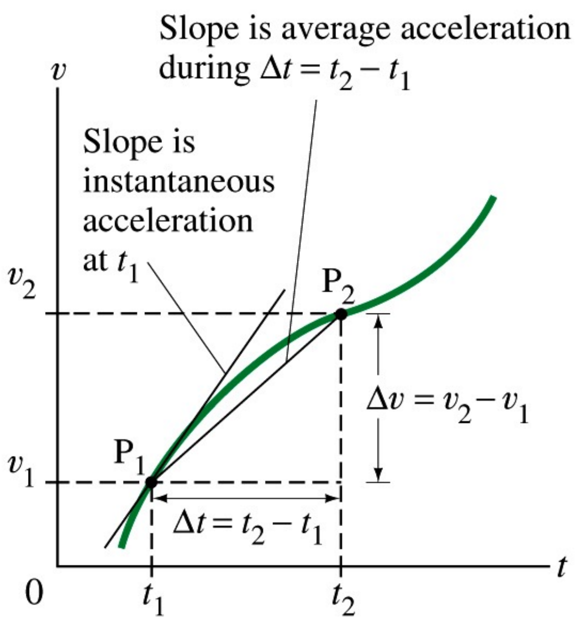


One Dimension

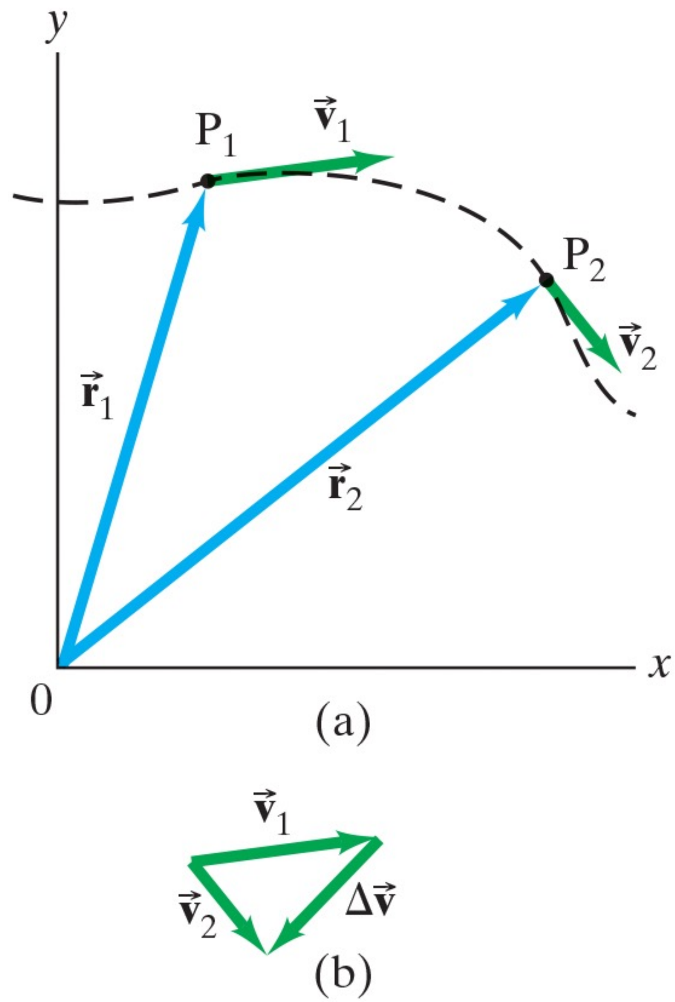


Two Dimensions

Acceleration



One Dimension



Two Dimensions

Constant acceleration (in 1D).

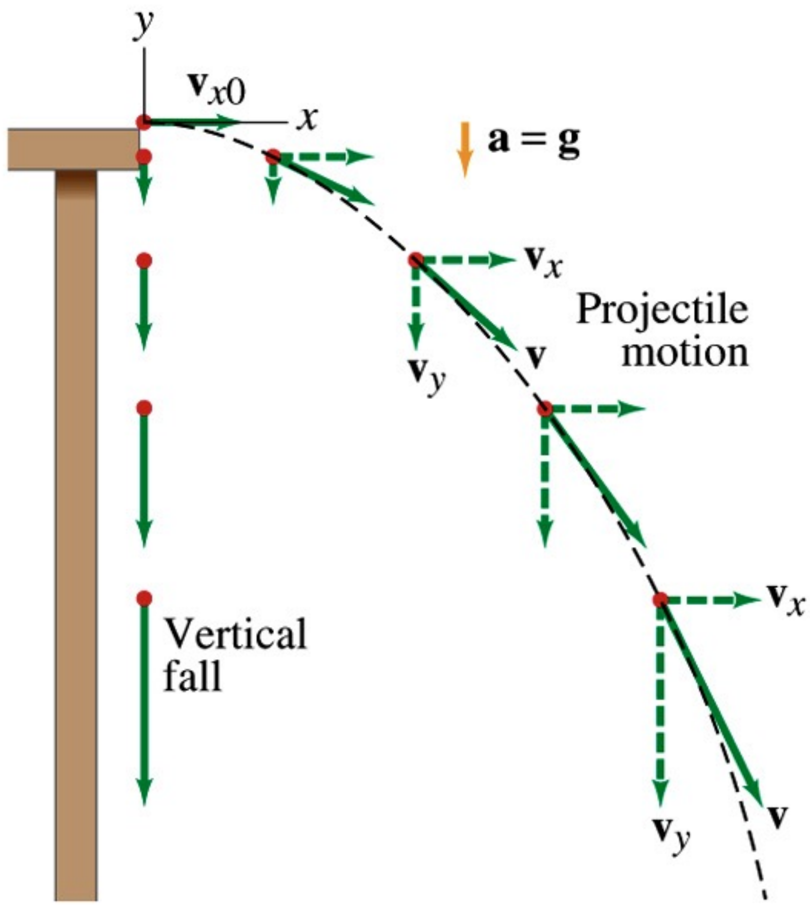
- In order to fully define the motion of an object if we know its acceleration, we need to have more information:
  - We need to know v_0, which is the velocity of the object at time $t = 0$ s.
  - We need to know x_0, which is the position of the object at time $t = 0$ s.
- Make sure the signs are consistent!

$$a = \frac{dv}{dt} = \text{constant}$$

$$v(t) = v_0 + at$$

$$x(t) = x_0 + v_0 t + \frac{1}{2} a t^2$$

Constant Acceleration (in 2D)



$$a_x = 0, a_y = -g$$

$$v_x(t) = v_{x0}$$

$$v_y(t) = v_{y0} - gt$$

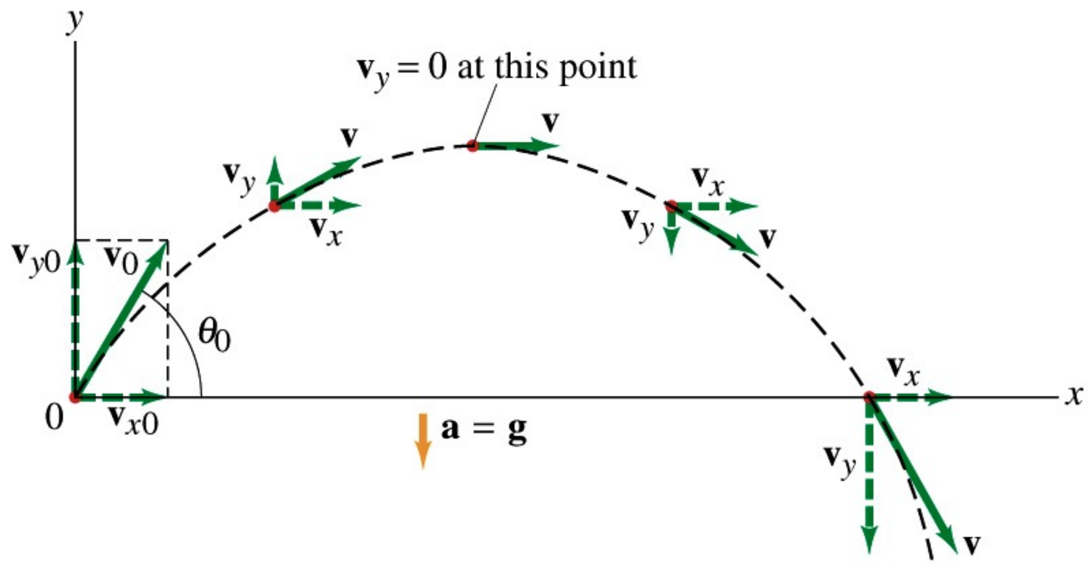
$$x(t) = x_0 + v_{x0}t$$

$$y(t) = y_0 + v_{y0}t - \frac{1}{2}gt^2$$

Motion in two dimensions: projectile motion.

- To study projectile motion, we decompose the motion into its two components:
- Vertical motion:
  - Defines how long it will take for the projectile to hit the ground:

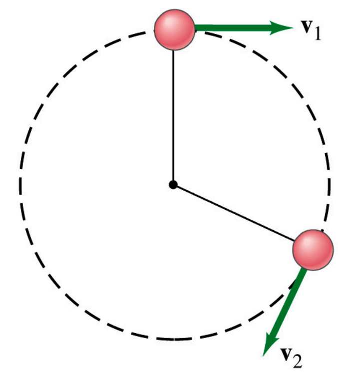
$$t = \frac{2v_0 \sin\theta_0}{g}$$

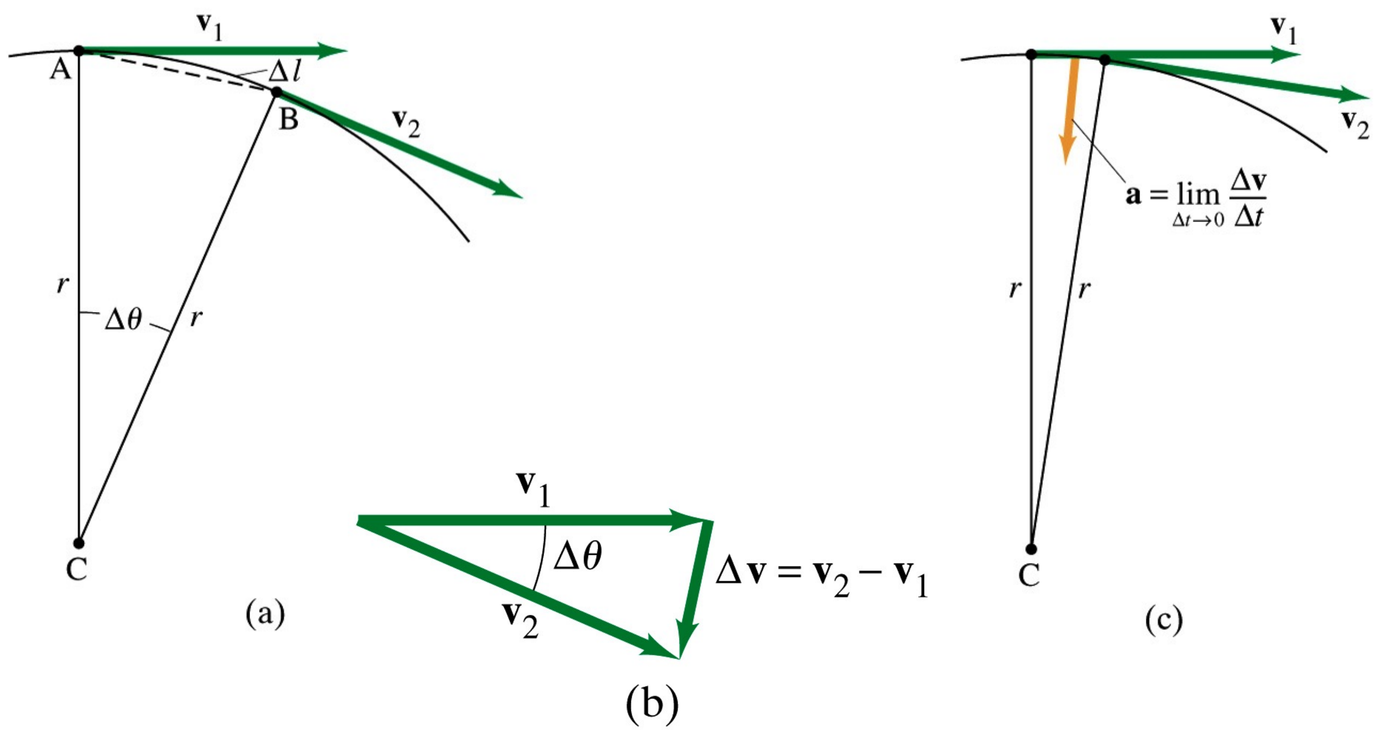


- Horizontal motion:
  - During this time interval, the distance traveled by the projectile is

$$x = (v_0 \cos\theta_0)\frac{2v_0 \sin\theta_0}{g} = \frac{v_0^2}{g}\sin 2\theta_0 = R$$

Circular Motion





Constant Circular Motion

- The circular motion of an object with period T can be described by the following equations:

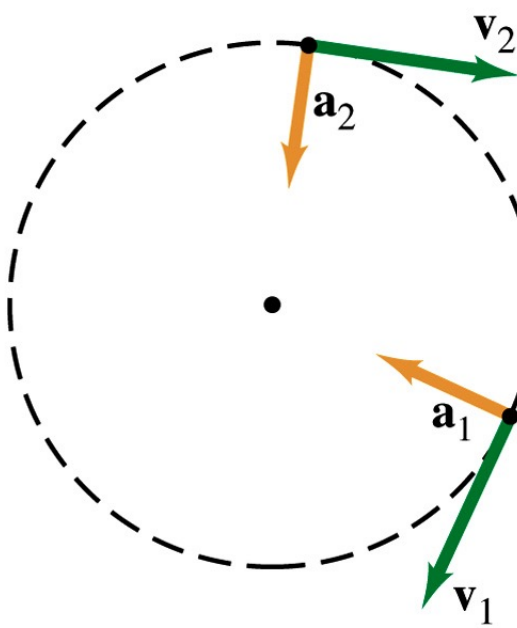
$$x(t) = r_0 \cos\left(\frac{2\pi t}{T}\right)$$

$$y(t) = r_0 \sin\left(\frac{2\pi t}{T}\right)$$

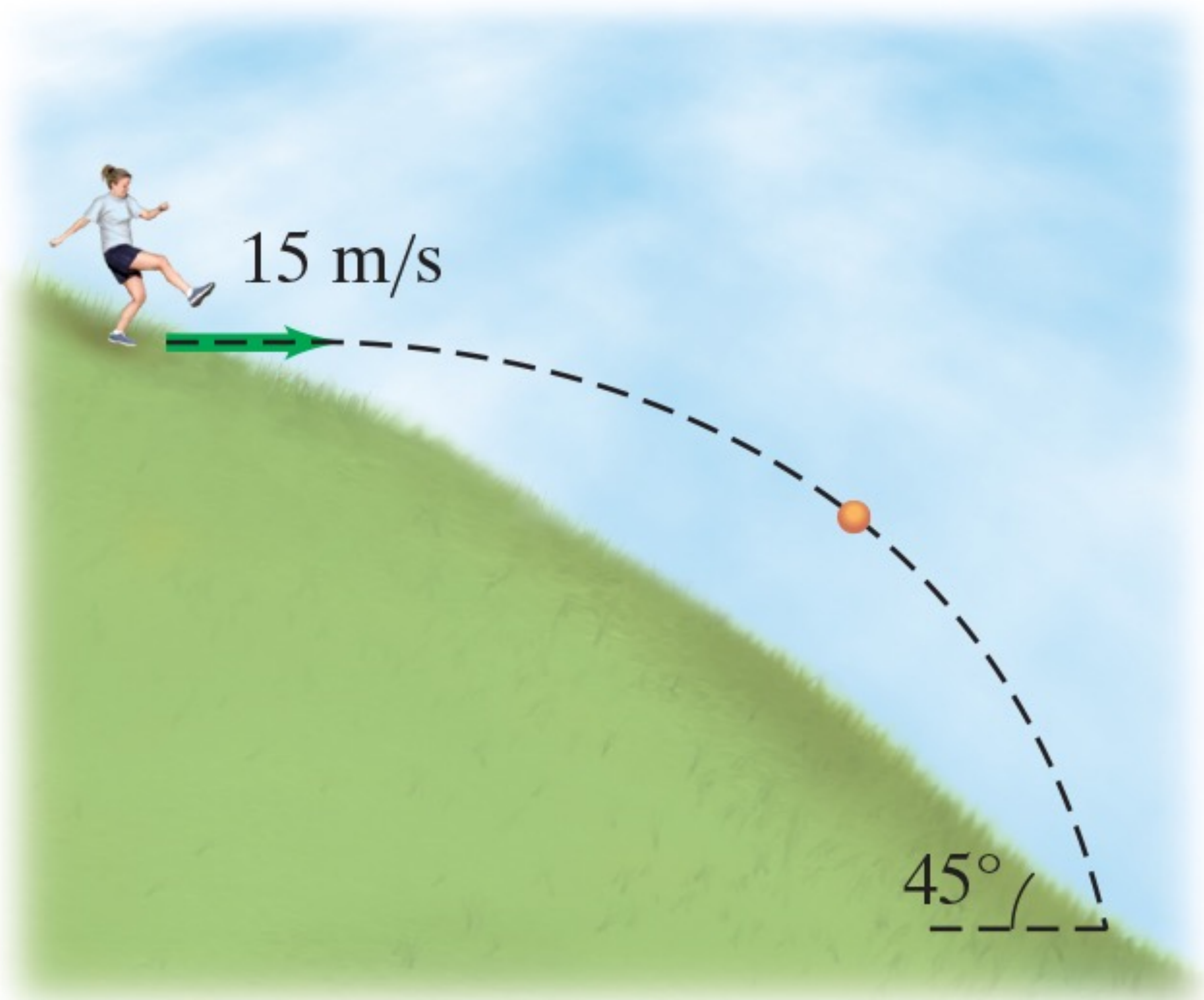
- Important facts to remember:
  - The acceleration vector points towards the center of the circle.
  - The magnitude of the acceleration is equal to

$$|a| = \frac{v_0^2}{r}$$

$$v_0 = \frac{2\pi r_0}{T}$$



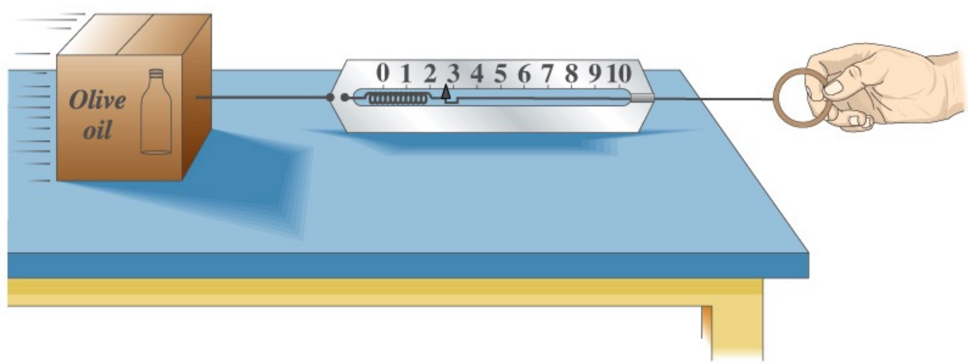
An example problem of motion in 2D.
How long does it take to hit the ground?



Any questions about motion?

Forces

- When an object all of a sudden changes its velocity and/or direction, we can always find an interaction between that object and its surroundings that is responsible for this change.
- We state that the surroundings exert a **force** on the object studied.
- Under the influence of a force, an object will accelerate.
- The force laws can be used to calculate the acceleration of an object based on the forces acting on it.

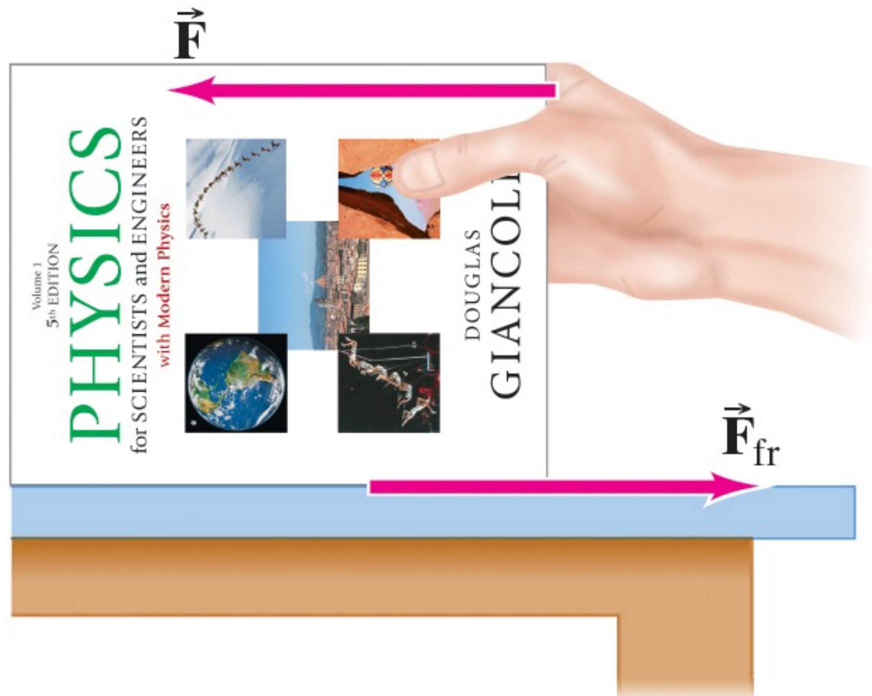


Newton's first law of motion.

- First Law:

  Consider a body on which no net force acts. If the body is at rest, it will remain at rest. If the body is moving with constant velocity, it will continue to do so.

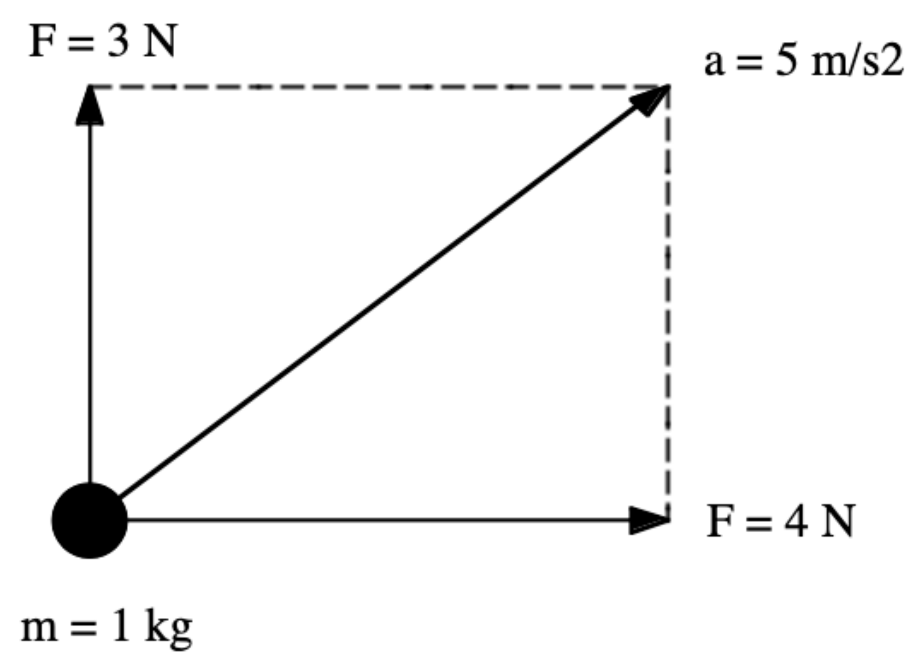
- Notes:
  - **Net force:** sum of ALL forces acting on the body.
  - An object at rest and an object moving with constant velocity both have **no acceleration**.



Newton's second law of motion.

Second Law:

The acceleration of an object is directly proportional to the net force acting on it and it inversely proportional to its mass. The direction of the acceleration is in the direction of the net force acting on the object:



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

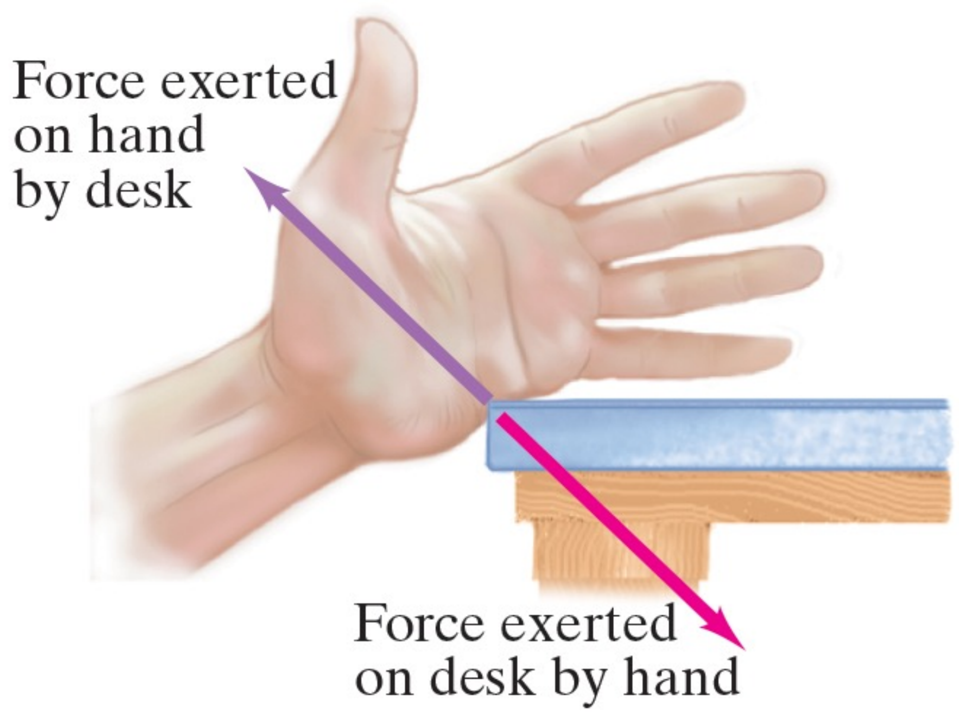
Newton's third law of motion.

Third law:

Suppose a body A exerts a force $\vec{F}_{BA}$ on body B. Experiments show that in that case body B exerts a force $\vec{F}_{AB}$ on body A. These two forces are equal in magnitude and oppositely directed:

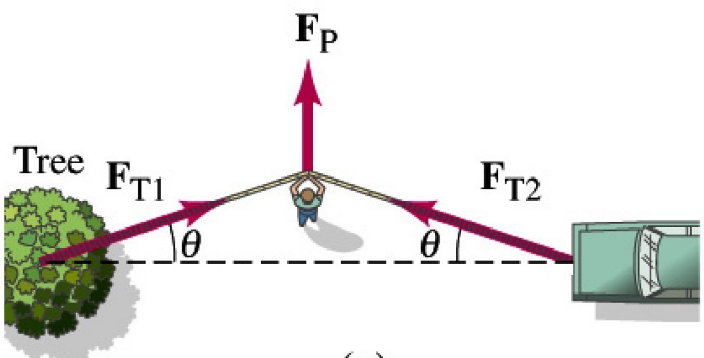
$$\vec{F}_{BA} = -\vec{F}_{AB}$$

Note: these forces act on different objects, and they do not cancel each other.

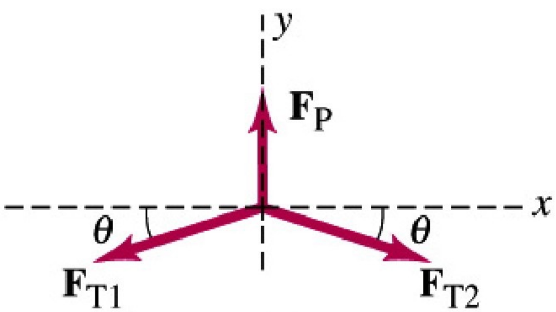


Newton's Laws of Motion
Problem Solving Strategies

- The first step in solving problems involving forces is to determine all the forces that act on the object(s) involved.
- The forces acting on the object(s) of interest are drawn into a free-body diagram.
- Apply Newton's second law to the sum of to forces acting on each object of interest.

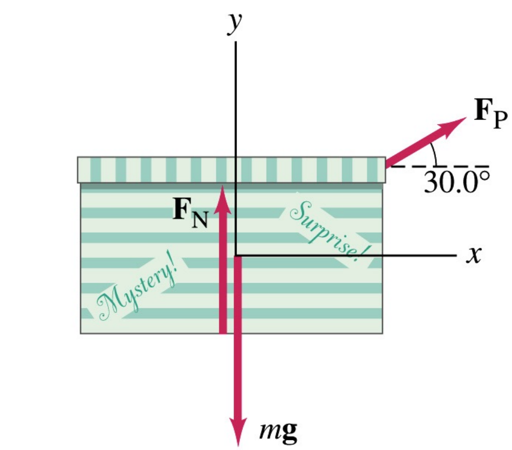


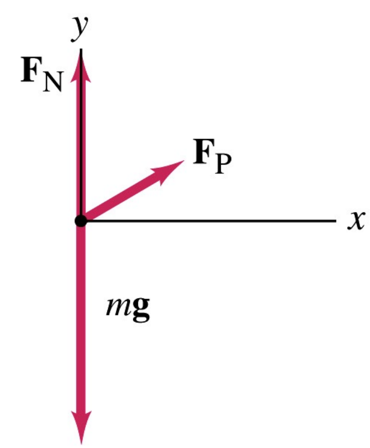
(a)

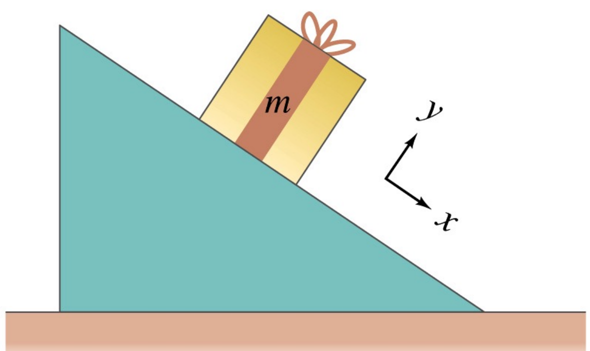


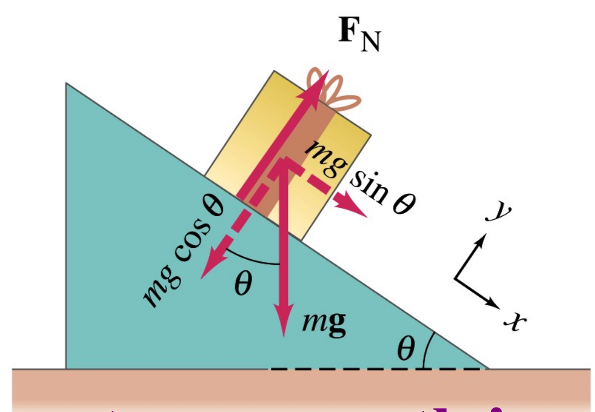
(b)

Problem Solving Strategies
Creating Free-Body Diagrams







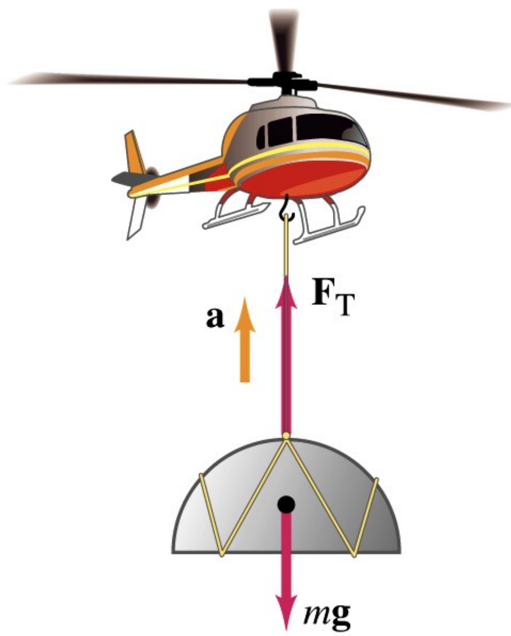


Note: choose your coordinate system correctly!

Maximize the number of forces parallel to the axes!

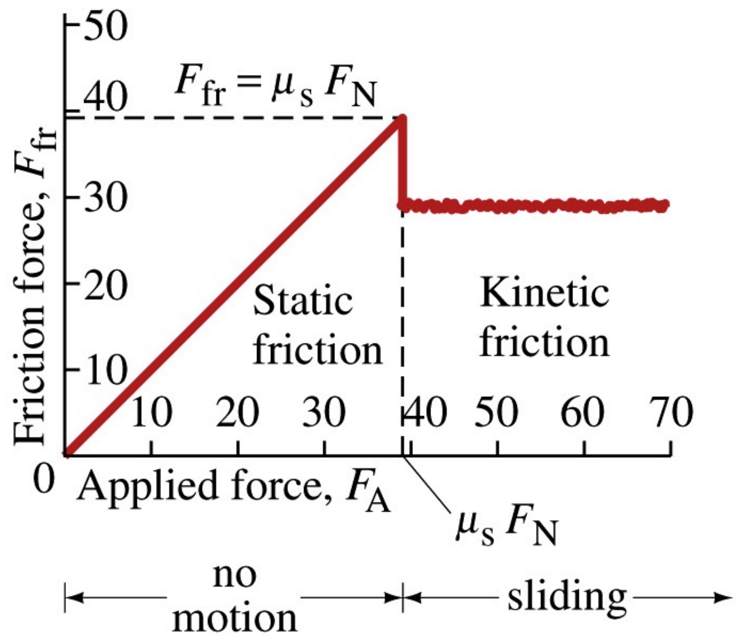
Problem Solving Strategies
The Net Force

- Determine if there is a net force acting on the system:
  - If the objects are moving with constant velocity (or are at rest), the net force must be zero.
  - If the object are accelerating, the net force can not be zero.
- If you know the acceleration, you know the net force!



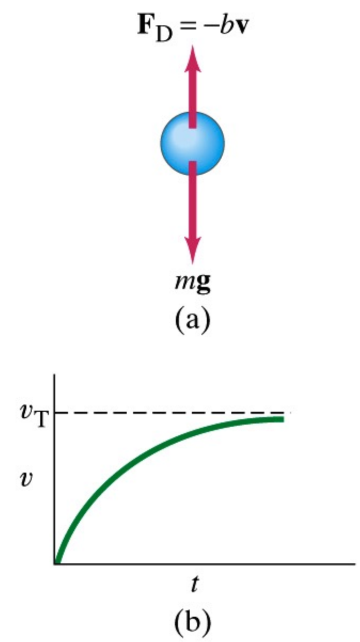
The Friction Force

- There are two different friction forces: the static friction force (no motion) and the kinetic friction force (motion).
- The static friction force increases with the applied force but has a maximum value.
- The kinetic friction force is independent of the applied force, and has a magnitude that is less than the maximum static friction force.



Air "Friction" or Drag

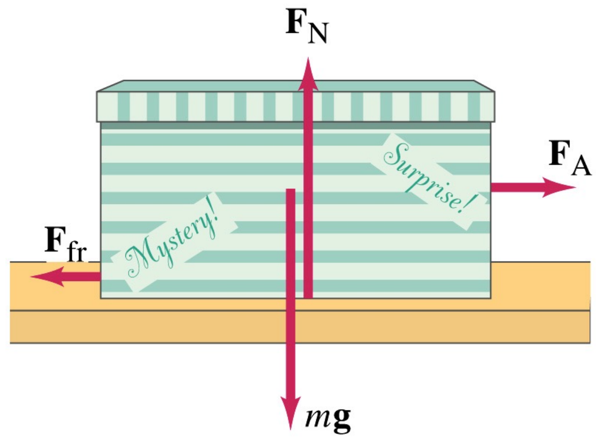
- Objects that move through the air also experience a "friction" type force.
- The drag force has the following properties:
  - It is proportional to the cross sectional area of the object.
  - It is proportional to the velocity of the object.
  - It is directed in a direction opposite to the direction of motion.
- The drag force is responsible for the object reaching a terminal velocity (when the drag force balances the gravitational force).

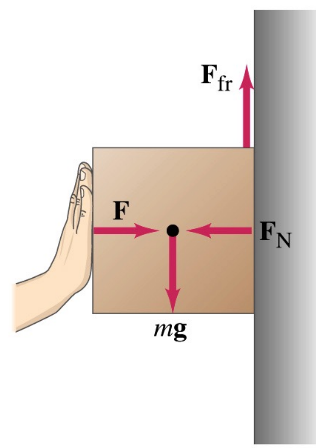


Friction and Normal Forces

- The maximum static friction force and the kinetic friction force are proportional to the normal force.
- Changes in the normal force will thus result in changes in the friction forces.

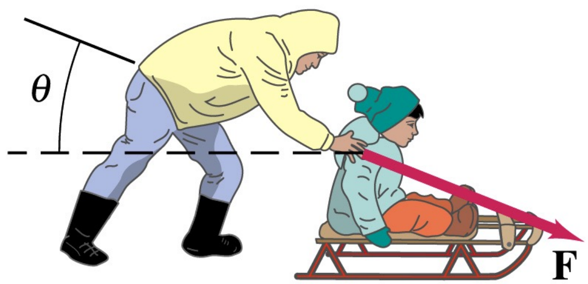
- **NOTE:**
  - The normal force will be always perpendicular to the surface.
  - The friction force will be always opposite to the direction of (potential) motion.

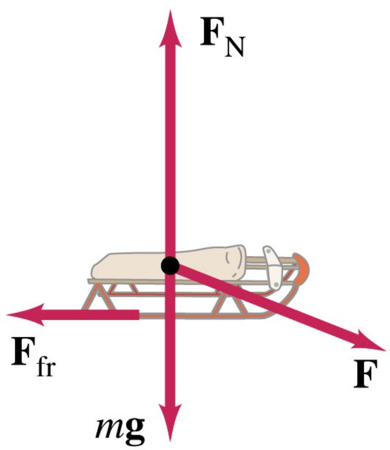




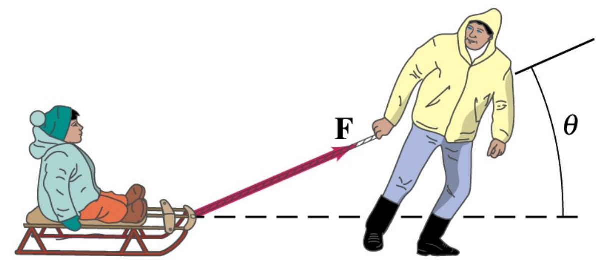
Pushing or Pulling
Changing the Normal Force

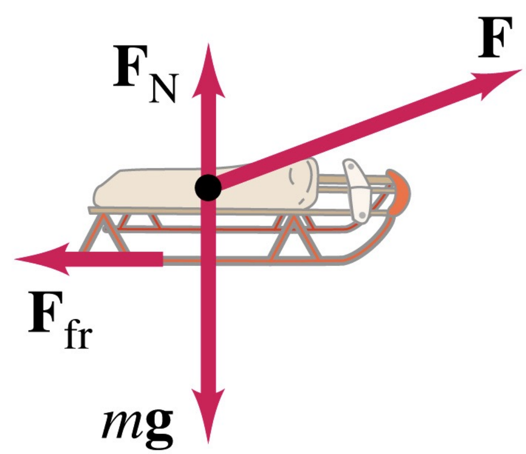
More Friction



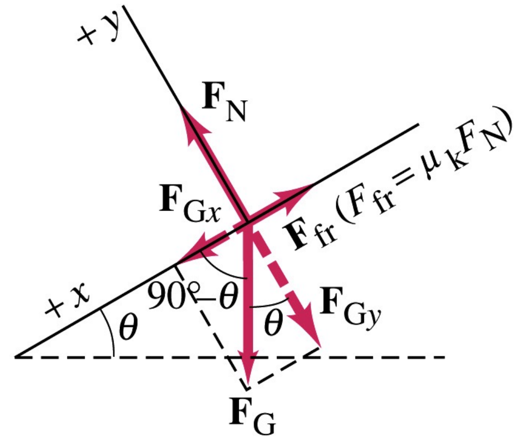


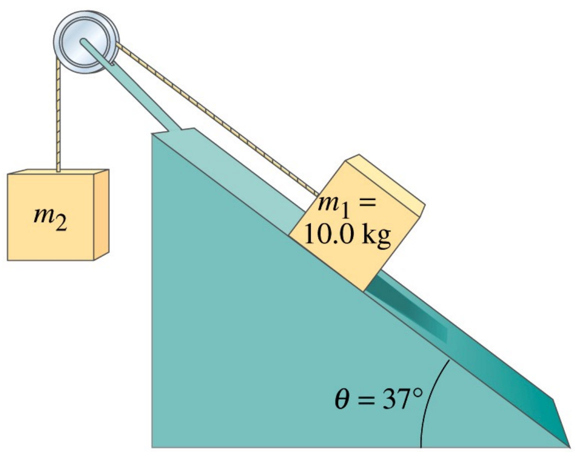
Less Friction

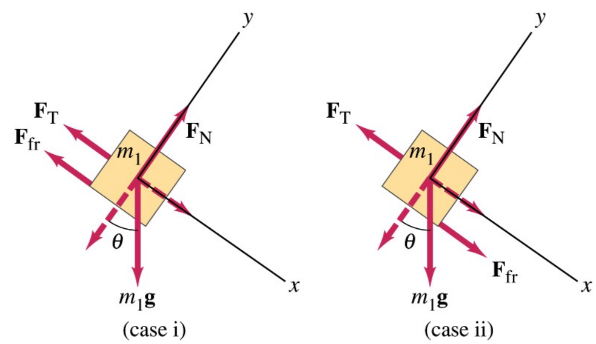




Calculating the Friction Force
More Free-Body Diagrams

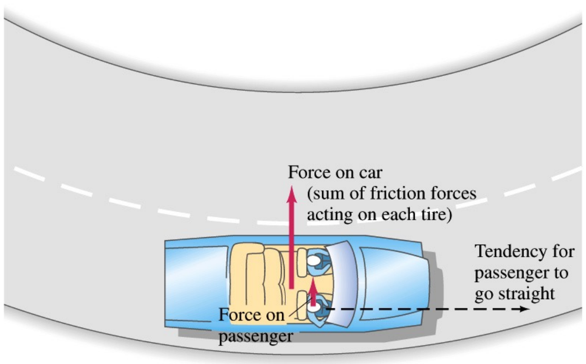


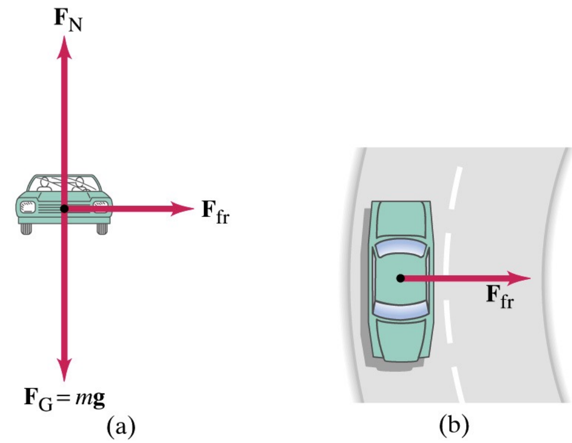


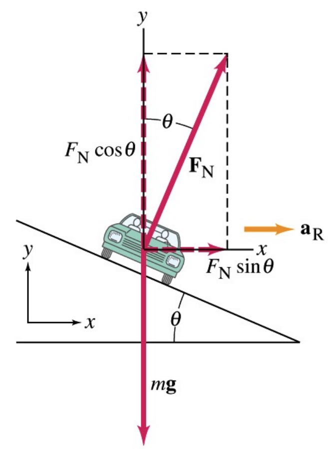


The direction of the friction force depends on the direction of motion

Calculating the Friction Force
More Free-Body Diagrams





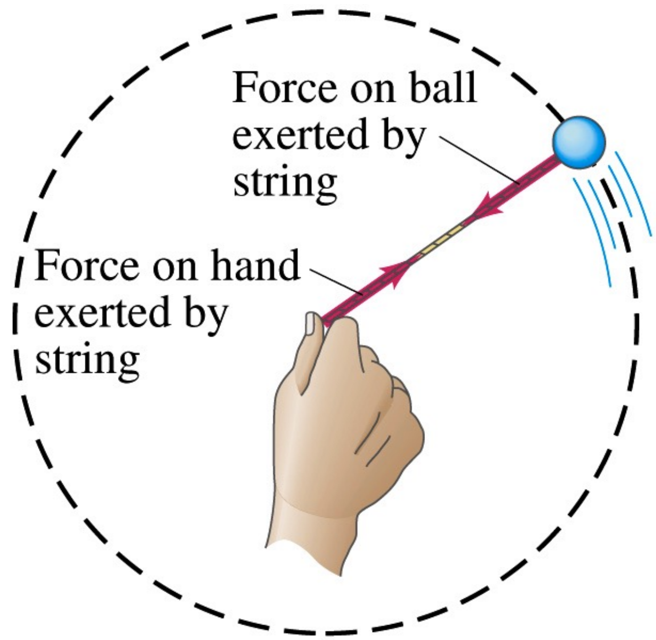


Circular Motion

- When we see an object carrying out circular motion, we know that there must be force acting on the object, directed towards the center of the circle.
- Note: now you must identify the force that can keep the object in its circular orbit.
- At no point in time will the net force on the ball be zero. Too often students will write for the net force on the object:

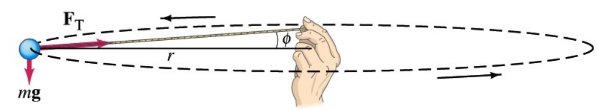
$$F_{net} = T - mv^2/r = 0$$

This is wrong …. But gets you the correct answer!!!!!

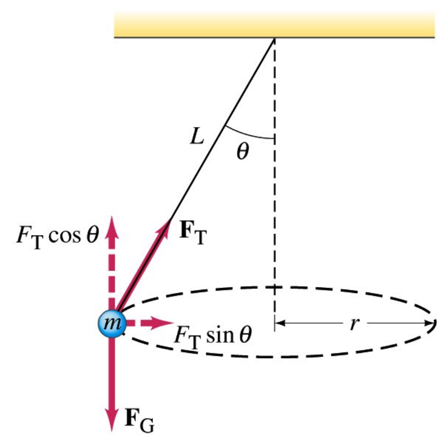


Circular Motion

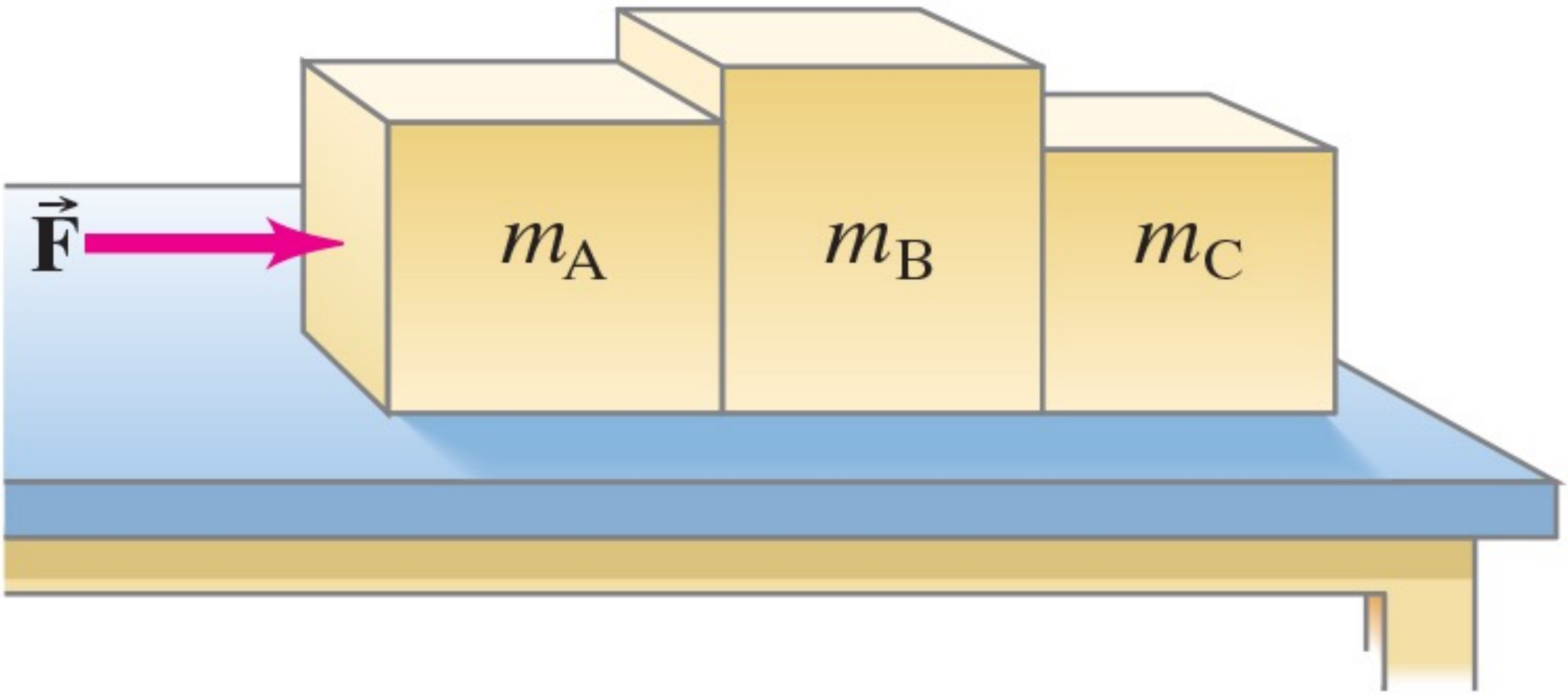
- In most cases, the string force not only has to provide the force required for circular motion, but also the force required to balance the gravitational force.



- Important consequences:
  - You can never swing an object with the string aligned with the horizontal plane.
  - When the speed increases, the acceleration increases up to the point that the force required for circular motion exceeds the maximum force that can be provided by the string.

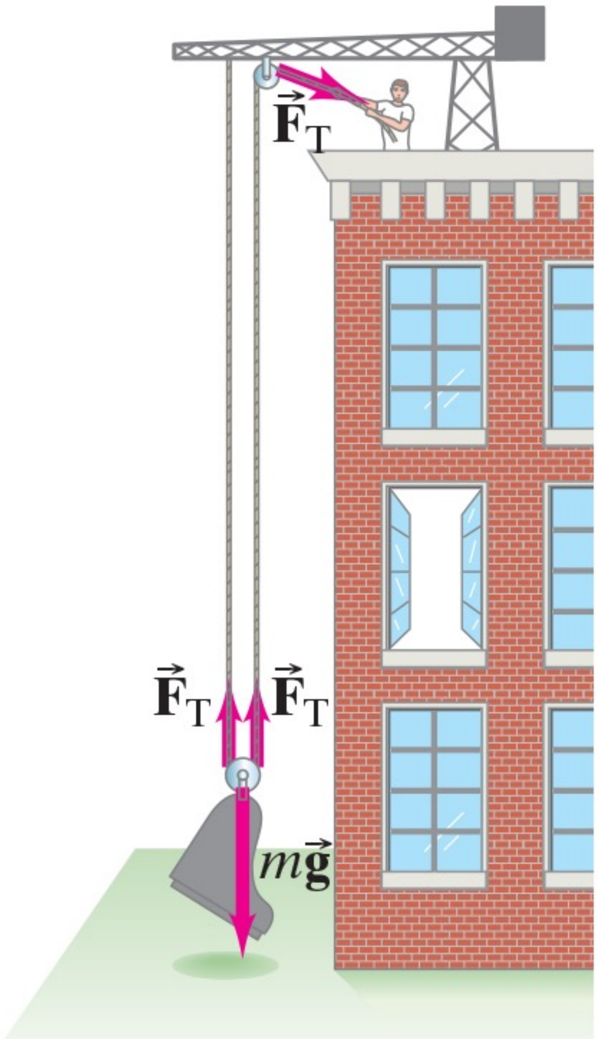


Examples: contact forces.

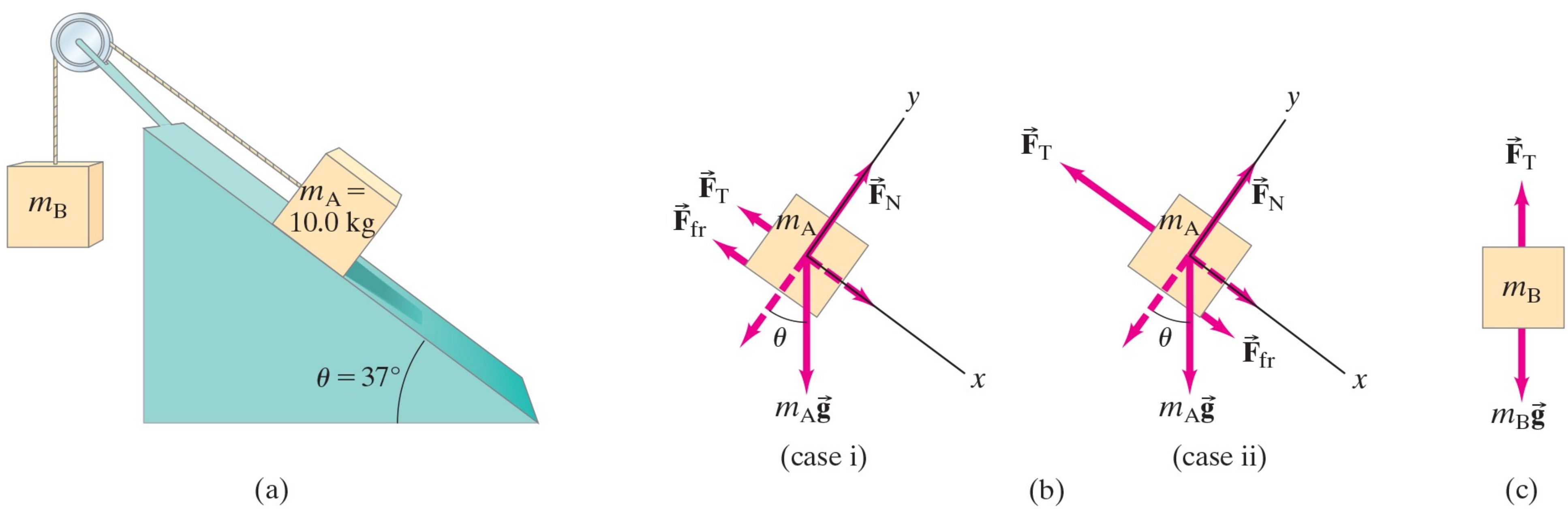


Examples: Pulleys.

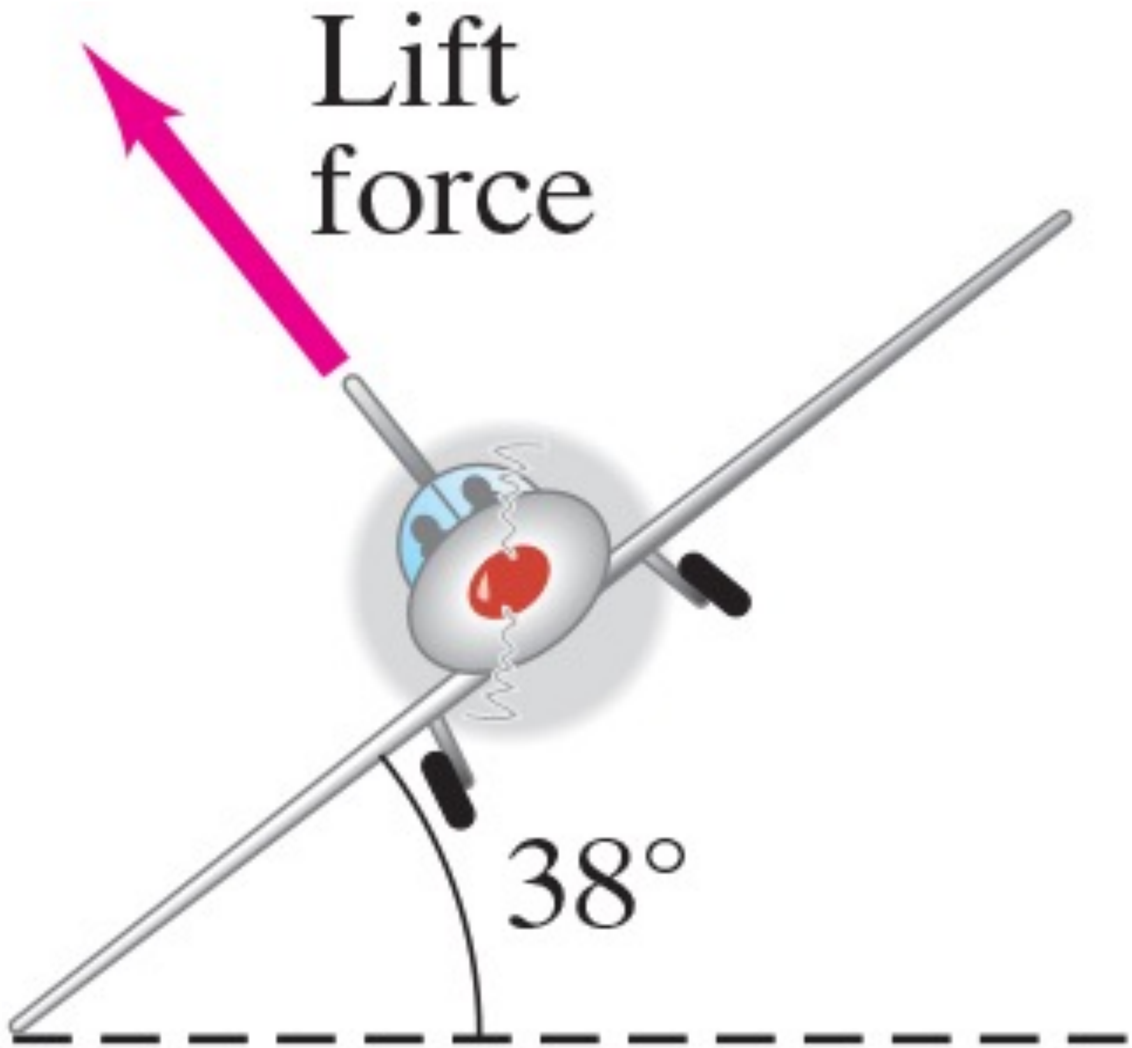
- Pulleys can be used to reduce the force required to lift object.
- In this example, the force applied is equal to the tension in the rope.
- But …. The force acting on the piano due to the tension in the rope is twice the tension.
- You can lift the piano with a force that is less than the weight of the piano.



Forces: the direction of the friction forces is determined by the direction of motion.



Forces: include all the forces in your free-body diagram.



Any questions about forces?

Final Remarks

- The hardest part of each problem is recognizing the approach to take. Different approaches may lead to the same answer, but can differ greatly in difficulty.

- A suggestion:
  - Look at the end of chapter problems. There is only a limited number of types of question one can ask.
  - But ……. Since the questions are grouped by section, you know already what approach to use based on the section to which the problems are assigned.
  - Some students benefit from copying the questions, cutting them out, writing the chapter/section numbers on the back, mixing them up, and then reading through them and determining what approach you would take if you would see that question on the exam (compare it with the focus of the section to which the problem was assigned).

Final Remark:

Good luck preparing for the exam.