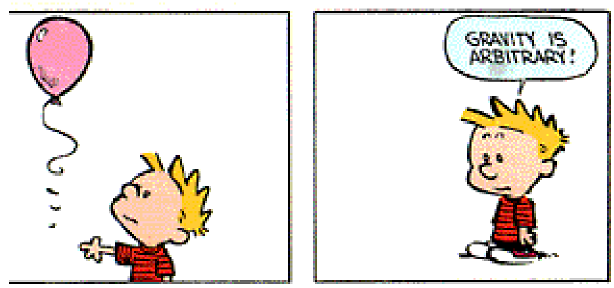
PHY131 F Fall 2020
Class 6

Today:

- 3.1 Force
- 3.2 Representing Forces with Vectors
- 3.3 How is Force Related to Motion?



(No, it isn't, Calvin. For an explanation of buoyant force, see Chapter 13, page 398)

1

Midterm Assessment 1

Due Sep 29 at 8:45pm **Points** 100 **Questions** 10
Available Sep 29 at 8:10pm - Sep 29 at 8:45pm 35 minutes
Time Limit 30 Minutes

This quiz is locked until Sep 29 at 8:10pm.

- Midterm Assessment 1 is based on Chapters 1, 2 and 3 of Etkina, plus materials from your first Practical.
- The format of this midterm assessment will be 10 multiple choice questions.
- Future midterm assessments may have a written or short-answer component that is marked by TAs, but not this one.
- This quiz is "open book"; allowed aids include the course notes, videos, and google-searches for static web-pages.
- However, you must work on the assessment **individually**. No group work or chats with other students are allowed during the assessment!

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This quiz is locked until Sep 29 at 8:10pm.

- The quiz will end 30 minutes after you start, or at 8:45pm, whichever comes *first*.
- You will only see one question at a time.
- You must submit each answer by clicking **Next** in order to see the next question; you will not have the ability to go back change any answer after it has been submitted.
- After completing all 10 questions you must click **Submit Quiz** before the time has ended.
- There are 3 conceptual questions and 7 numerical questions.
- So far 55 students have registered to take the Alternate sitting at 10:10pm.

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Dynamics

- Kinematics (Ch.2) is the study of *how* things move.
- **Dynamics** is the study of *why* things move.
- Consider this “thought experiment”:
- James Bond is standing still in the middle of an ice-covered lake.
- If the surface and the bottoms of his shoes were both *perfectly slippery*, no stickiness at all, would he be able to move?
- What if someone threw him a rope?

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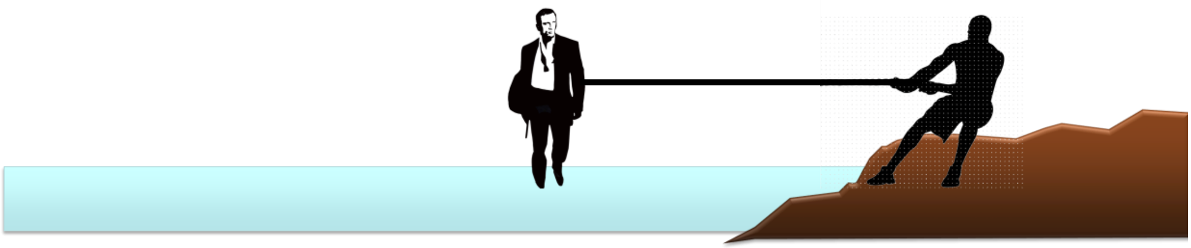
System, Environment, External Interactions.

- A **system** is the object or group of objects that we choose to analyze. We often draw a little dashed line around the system.
- Everything outside that system is called its **environment** and consists of objects that might interact with the system (touch, push, or pull it) and affect its motion through **external interactions.**



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What is a force?

- A force is a physical quantity that characterizes how hard and in what direction an external object pushes or pulls on the system.
- We say that an external object exerts a force *on* the system.
- From the system's perspective, it has a force *exerted* on it
- A force is either a contact force (like normal) or a long-range force (like gravity).
- The S.I. unit of force is the Newton (N)
- N is not a fundamental unit; it can be broken down into fundamental units:

$$1\ \mathrm{N} = 1\ \mathrm{kg\ m\ s^{-2}}$$

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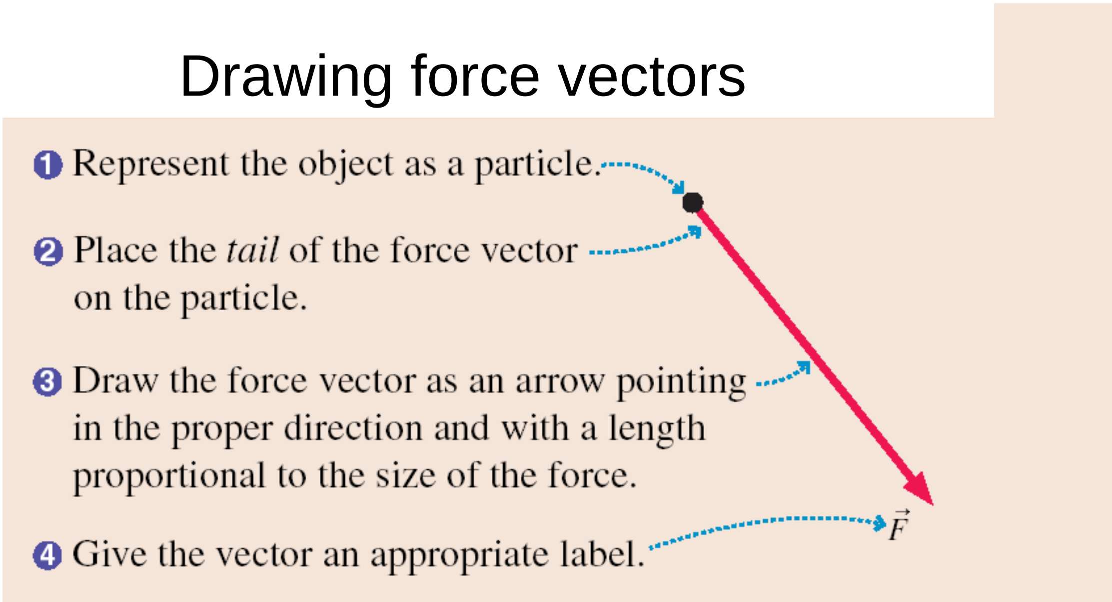
Drawing force vectors



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Force Diagram

- A **force diagram** (sometimes called a *free-body diagram*) represents the forces that objects in a system's environment exert on it.
- We represent the system by a dot to show that we model it as a point-like object.
- Arrows represent the forces.

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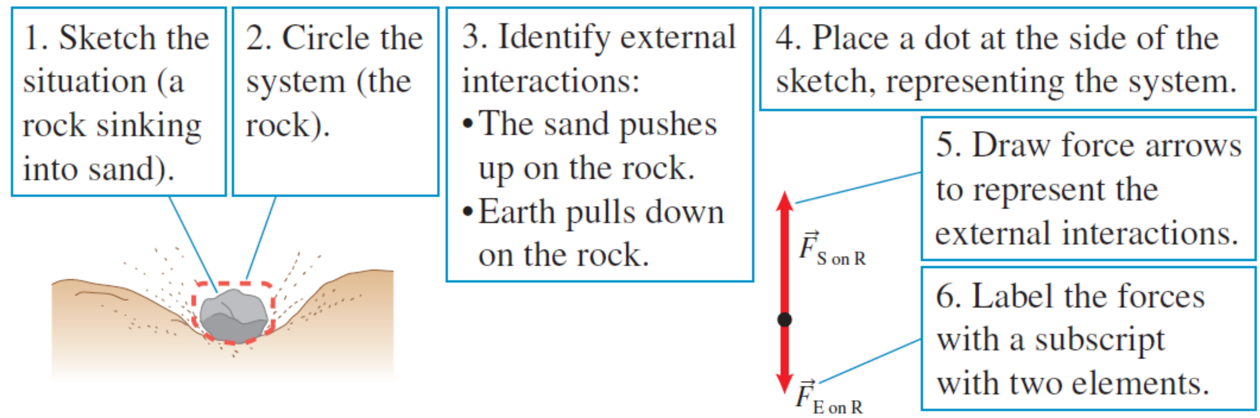
PHYSICS TOOL BOX 3.1 Constructing a force diagram



- Remember that on the force diagram, you only draw forces exerted **on** the system.
- Do not draw forces that the system exerts on other objects.

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Poll

- You toss a ball straight up in the air.
- Immediately after you let go of it, what forces are acting on the ball?

1. The downward force of gravity from the Earth.
2. An upward throwing force from your hand.
3. A small downward drag-force from air resistance.

A. 1, 2 and 3
B. 1 and 3
C. 1 and 2
D. 1 only
E. 2 and 3

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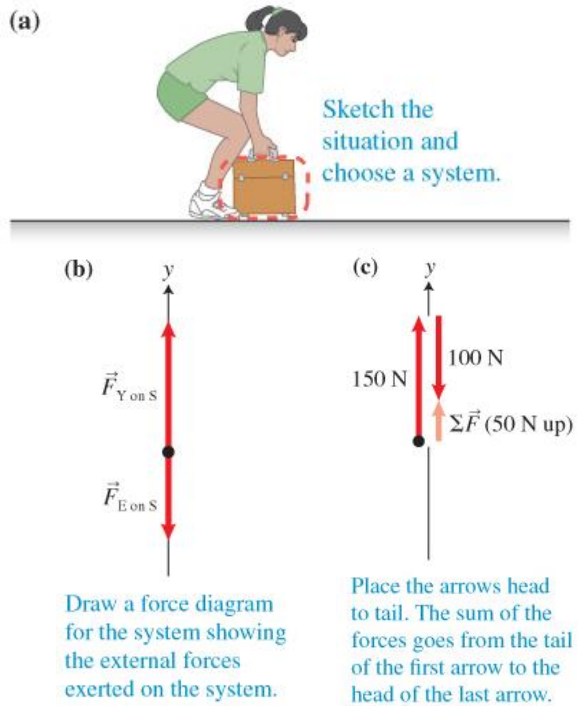
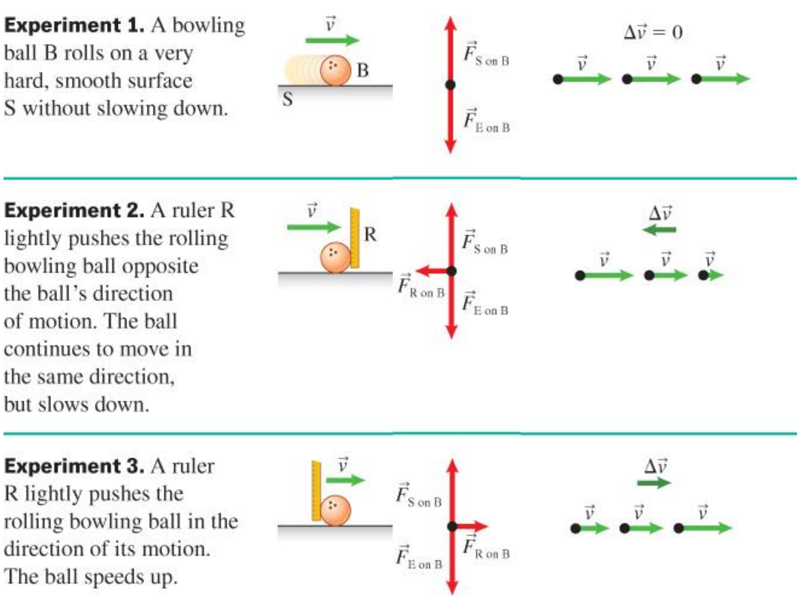
Net Force $\sum \vec{F}$



- The sum of the force vectors is **not** a new force being exerted.
- Rather, it is the **combined effect** of all the forces being exerted on the system.
- Because of this, the resultant vector should never be included in the force diagram for that system.

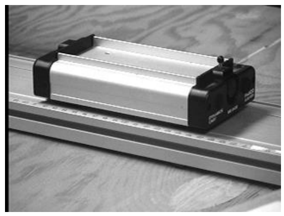
Observing a bowling ball



- "System" = bowling ball.
- In all experiments, the vertical forces on the system add to zero and cancel each other.
- **Experiments 1:** The net force on the ball is zero, the ball's velocity is constant. Zero acceleration.
- **Experiments 2 & 3.** A constant net force produces a constant acceleration. The velocity changes at a constant rate.

1 Newton's First Law of motion

For an observer in an inertial reference frame, when no other objects exert forces on a system or when the forces exerted on the system add to zero, the system continues moving at constant velocity (including remaining at rest).



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What is Mass?

- Mass is a scalar quantity that describes an object's inertia.
- It describes the amount of matter in an object.
- **Mass is an intrinsic property of an object.**

- It tells us something about the object, regardless of where the object is, what it's doing, or whatever forces may be acting on it.

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2 Newton's Second Law

The acceleration of a system is proportional to the vector sum of all forces being exerted on the system and inversely proportional to the mass of the system.

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

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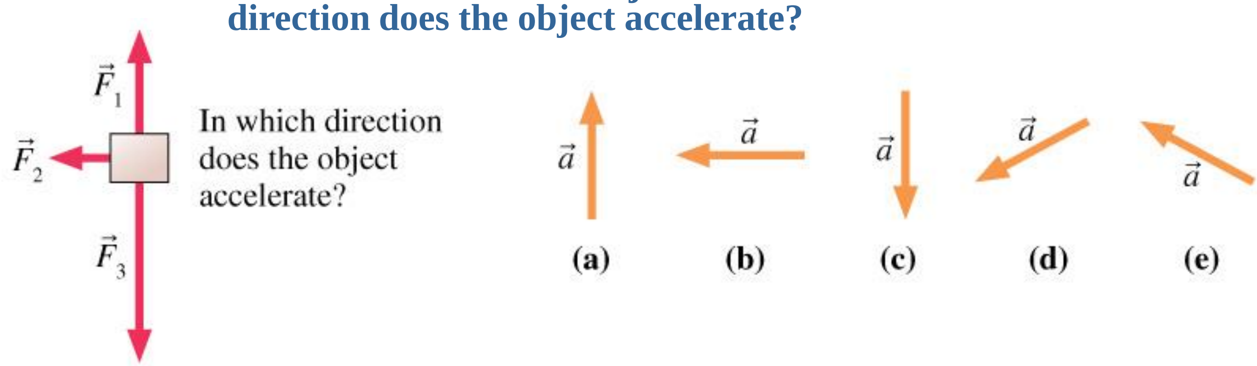
Poll

Three forces act on an object. In which direction does the object accelerate?



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Projectile Motion Example

- An angry bird of mass $m = 0.12\ \text{kg}$ is flying through the air. His wings are tucked in due to anger, so, let's assume that air resistance is negligible.
- What is the acceleration of the bird?

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- Newton's Laws only apply in a "inertial reference frames". They are not valid if your reference frame is accelerating!
- An **inertial reference frame** is one that is **not accelerating.**

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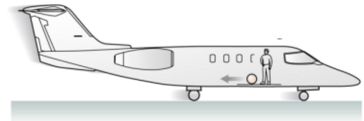
Poll



- You are in a plane which is accelerating forward on a runway.
- Some careless person has left a tennis ball in the aisle. You notice this tennis ball is accelerating toward the back of the plane.
- Newton's Second Law states that $\vec{a} = \sum \vec{F}/m$, so there must be a net force on the tennis ball directed toward the back of the plane. What is the source of this backward net force?

A. Air resistance
B. The plane must be at an angle, so a component of gravity provides the net force toward the back of the plane.
C. The inertial force
D. The normal force
E. Newton's second law is not valid in your reference frame.

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List of Forces you might encounter

The forces we deal with most often in PHY131/132 are:

- Gravitational Force
- Normal Force
- Tension
- Kinetic Friction
- Static Friction
- Spring Force
- Electric
- Magnetic
- Thrust (like from a rocket)
- Drag force (fluid resistance)
- Muscle

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Normal Force: Board on Dog

"The diving board exerts a normal force on the dog."

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Tension of Rope on Harlow

"The rope exerts a tension force on Harlow."

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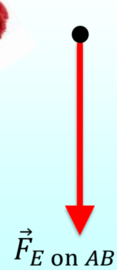
Gravity



- $\vec{F} = m\vec{g}$ when the object is near the surface of Earth
- $\vec{g} = 9.80\,\frac{\text{N}}{\text{kg}}, down$
- Also called "weight"

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Gravity for Earthlings

If an object of mass m is near the surface of a large planet called Earth with radius R = 6370 km and mass $M = 5.97 \times 10^{24}$ kg, then there will be a **gravitational force** acting on the object (often called its "weight"):

$$F_{E \text{ on } O} = m_O g$$

Where the force acts toward the centre of the planet (ie "down"), and g = 9.8 N/kg.

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Poll

- When I stand on a scale in my bathroom it reads 185 pounds. 2.2 pounds = 9.8 Newtons, so this means the upward force on my feet when I am standing still is 185 lbs (9.8 N / 2.2 lbs) = 824 N.
- If I ride an elevator which is accelerating upward at 1.5 m/s^2, what is the upward force on my feet?
- With no calculations, take a wild guess from this list:

A. 824 N
B. 950 N
C. 698 N
D. 0 N
E. –824 N

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Before Class 7 on Friday

- Consider the following reasoning, and identify the mistake:
- “When you pull a wagon, Newton’s 3rd law states that the wagon pulls back on you with an equal and opposite force. These forces should cancel each other. So it is impossible to accelerate the wagon!”

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