Announcements 9 Mar 09

- Homework #5
  - Homework #5 Tactics Box 4.4 problem (part D) is tricky to draw force vectors
    → be sure to draw the vector from the black dot
    → be sure to draw vectors horizontal or vertical
- Homework #6
  - Written homework due on Friday in class
  - Online homework due on Tue March 24 by 8 am
- Office hours
  - Today: 3:00 to 4:30 pm (30 mins. earlier than usual)

Newton's Second Law

Newton's second law An object of mass m subjected to forces $\vec{F}_1$, $\vec{F}_2$, $\vec{F}_3$, . . . will undergo an acceleration $\vec{a}$ given by

$$\vec{a} = \frac{\vec{F}_{net}}{m} \qquad (4.5)$$

where the net force $\vec{F}_{net} = \vec{F}_1 + \vec{F}_2 + \vec{F}_3 + \cdots$ is the vector sum of all forces acting on the object. **The acceleration vector $\vec{a}$ points in the same direction as the net force vector $\vec{F}_{net}$.**

Connection between motion and force

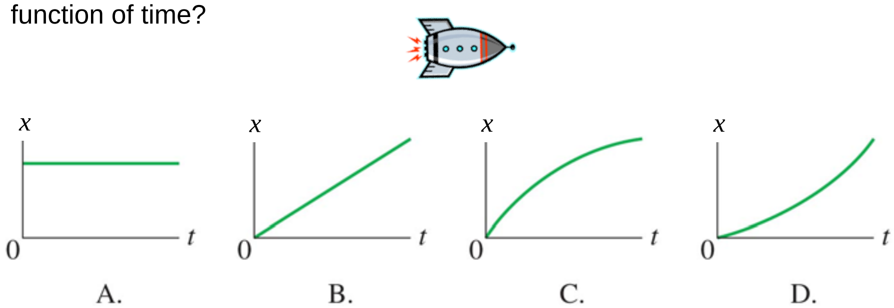
Mass = property of an object that determines how it accelerates in response to an applied force

Units of Force: 1 *Newton* = (1 kg) x (1 m/s^2)
from $\vec{F}_{net} = m\vec{a}$

Force and Graphs Question 1

PRS

A rocket in space, initially at rest, fires its main engines at a constant thrust. Which of the diagrams below best represents the *position* of the rocket as a function of time?



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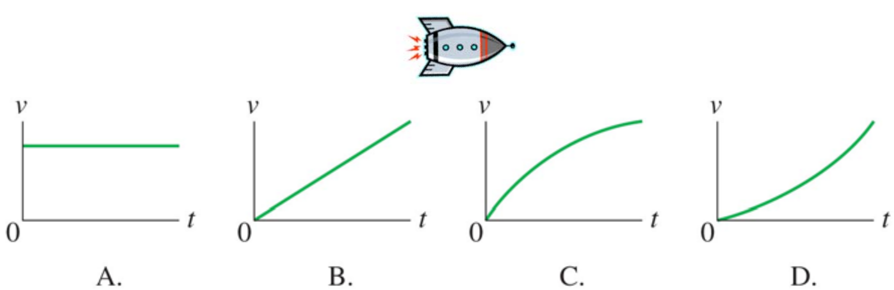
Force and Graphs Question 2

PRS

A rocket in space, initially at rest, fires its main engines at a constant thrust. *As it burns fuel, the mass of the rocket decreases*. Which of the diagrams best represents the *velocity* of the rocket as a function of time?



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Interactions Between Objects

- Newton's 2nd law describes the change in the motion of a *single* object under the influence of one or more external forces (external to the "system" composed of a single object)
- **How do we describe interactions between two objects?**

Action / reaction pair:

- **Left sumo wrestler exerts a force on right sumo wrestler**
- **Right sumo wrestler exerts a force on left sumo wrestler**
- **One force does not exist without the other, they form a *pair***

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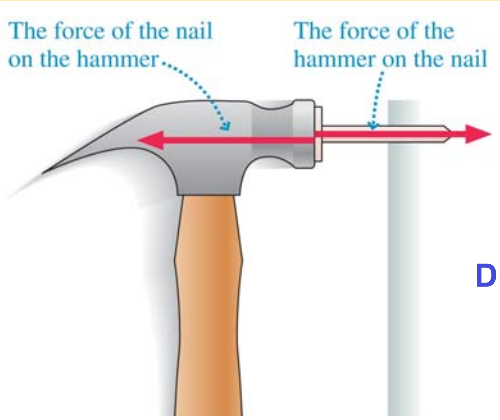
Newton's Third Law

Newton's third law Every force occurs as one member of an action/reaction pair of forces.

- The two members of an action/reaction pair act on two *different* objects.
- The two members of an action/reaction pair point in *opposite* directions, and are *equal in magnitude*.



DEMO:
push-me pull-me carts

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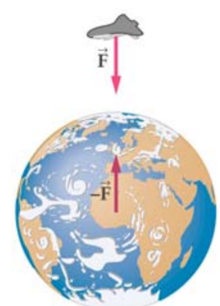
Newton's Third Law: revenge of the target

v = 1600 ft / s   1800 ft / s 2000 ft / s

The target exerts a force on the bullet that has magnitude equal that of the bullet on the target

Are you pulling my leg?

Space shuttle in orbit around the Earth exerts a force on the Earth that is equal (and opposite) to the force exerted by the Earth on the shuttle



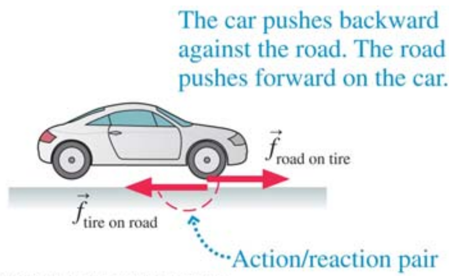
Effect of the force on the shuttle (bug) is much greater than the effect on the Earth (windshield) because of the much lower shuttle (bug) mass
➔ acceleration **a = F / m**

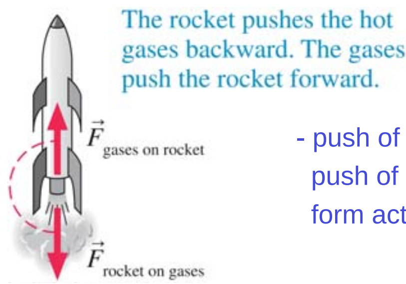
A bug hitting a car's windshield exerts the same amount of force on the windshield as the windshield exerts on the bug

3rd Law Application: Propulsion

A system with an internal source of energy can apply a force of propulsion

- static friction allows car to move forward





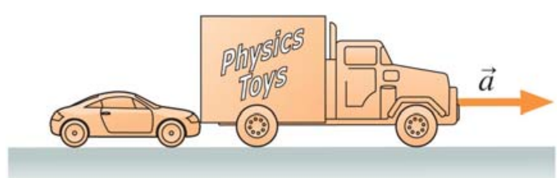
- push of rocket on gases + push of gases on rocket form action/reaction pair

3rd Law Question

PRS

A small car is pushing a larger truck that has a dead battery. The mass of the truck is larger than the mass of the car. Which of the following statements is true?

A. The car exerts a force on the truck, but the truck doesn't exert a force on the car.
B. The car exerts a larger force on the truck than the truck exerts on the car.
C. The car exerts the same amount of force on the truck as the truck exerts on the car.
D. The truck exerts a larger force on the car than the car exerts on the truck.
E. The truck exerts a force on the car, but the car doesn't exert a force on the truck.



Identifying forces for interacting objects

MP TACTICS BOX 4.4 Identifying forces for interacting objects — Exercises 23–27

1. **Identify those objects whose motion you wish to study.** These objects make up the system; the environment is everything else.
2. **Draw each object separately.** Place them in the correct position relative to each other.
3. **Identify all forces on the system.** For each object in the system, use the techniques of Tactics Box 4.2 to find the forces acting on that object.
4. - **Identify the action/reaction pairs.** For each force acting on an object, decide if it is of the form $\vec{F}_{\text{A on B}}$, where A and B are *both* objects in the system. If so, it is an internal force and forms an action/reaction pair with $\vec{F}_{\text{B on A}}$. Label the forces in a pair using notation like $\vec{F}_{\text{car on truck}}$ and $\vec{F}_{\text{truck on car}}$.
   - **Identify the external forces.** External forces are forces of the environment on an object in the system. Name each external force with its appropriate symbols such as $\vec{n}$ or $\vec{w}$. When needed, use subscripted labels such as $\vec{w}_1$ and $\vec{w}_2$ to distinguish between similar forces acting on different objects.
5. **Draw separate free-body diagrams for each object.** For each object, include the forces acting on it found in Step 3. Connect the force vectors of action/reaction pairs with dotted lines.

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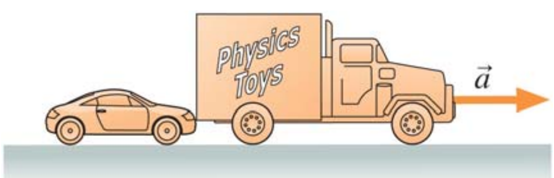
3rd Law Question: free-body diagrams



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