Announcements 6 Mar 09

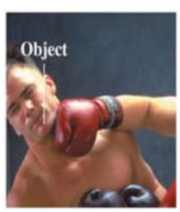
- **Homework**
  - Written homework #5 due on Monday (@ start of class)
  - Online homework #5 due on Tuesday (by 8 am)

Force and Motion

A force...

CAUSE

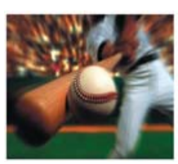
... is a push or pull.



... acts on an object.

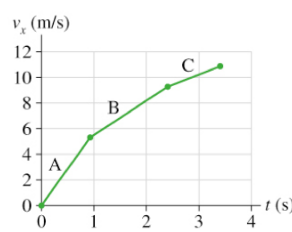
... requires an agent.

... is a vector.



... is a contact force or a long-range force.

EFFECT



acceleration

How are force and motion related?

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

$$\vec{a} = \frac{\vec{F}_{\text{net}}}{m} \tag{4.5}$$

where the net force $\vec{F}_{\text{net}} = \vec{F}_1 + \vec{F}_2 + \vec{F}_3 + \cdots$ 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 $\vec{F}_{\text{net}}$.**

Connection between motion and force

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

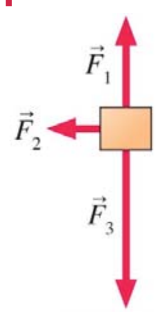
Units of Force: 1 *Newton* = (1 kg) x (1 m/s^2)

from $\vec{F}_{net} = m\vec{a}$

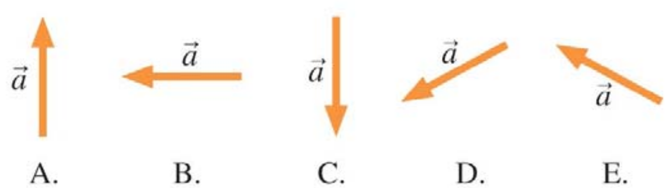
Net Force Question

PRS

Three forces act on an object.



In which direction does the object accelerate?



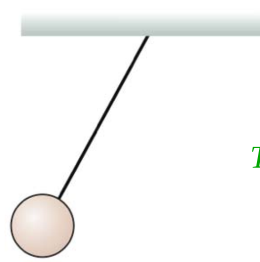
Free-body Diagrams

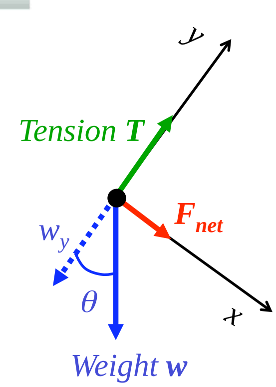
TACTICS BOX 4.3 Drawing a free-body diagram Exercises 17–22

1. **Identify all forces acting on the object.** This step was described in Tactics Box 4.2.
2. **Draw a coordinate system.** Use the axes defined in your pictorial representation (Tactics Box 2.2). If those axes are tilted, for motion along an incline, then the axes of the free-body diagram should be similarly tilted.
3. **Represent the object as a dot at the origin of the coordinate axes.** This is the particle model.
4. **Draw vectors representing each of the identified forces.** This was described in Tactics Box 4.1. Be sure to label each force vector.
5. **Draw and label the *net force* vector $\vec{F}_{net}$.** Draw this vector beside the diagram, not on the particle. Or, if appropriate, write $\vec{F}_{net} = \vec{0}$. Then check that $\vec{F}_{net}$ points in the same direction as the acceleration vector $\vec{a}$ on your motion diagram.

Free-Body Diagram Example

A ball, hanging from the ceiling by a string, is pulled back and released. Draw a free-body diagram just after the ball is released.





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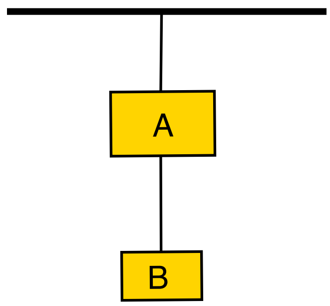
Along string (y axis):
net force = 0
i.e. $T = w_y = w \cos\theta$
$\Rightarrow$ *net force is along x*

Identifying Forces: Example 2

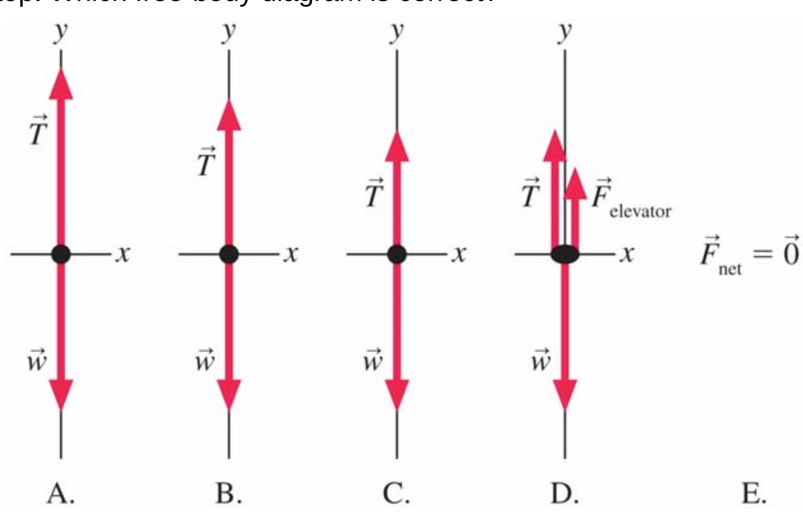
Block A hangs from the ceiling by a rope. Another block B hangs from A. Identify the forces acting on A.



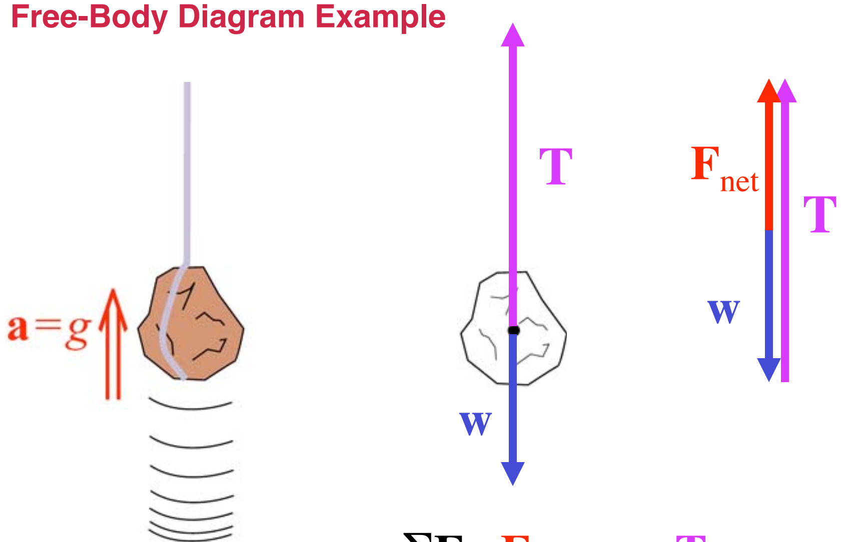
Free-Body Diagram Question

PRS

An elevator suspended by a cable is moving upward and slowing to a stop. Which free-body diagram is correct?



Free-Body Diagram Example



Pulled by string,
accelerating upwards at g

$$\Sigma \mathbf{F} = \mathbf{F}_{net} = \mathbf{w} + \mathbf{T} = m\mathbf{a}$$

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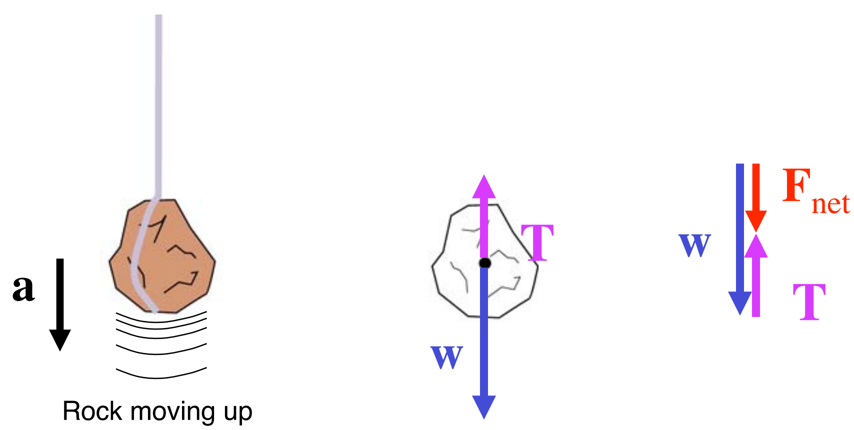
Free-Body Diagram Example



Rock moving up
but slowing down

$$\Sigma \mathbf{F} = \mathbf{F}_{net} = \mathbf{w} + \mathbf{T} = m\mathbf{a}$$

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Newton's 2nd Law Question

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Which of the following situations does **NOT** require that a net force act on the object?

A. An object speeding up.

B. An object changing its direction.

C. An object moving in a circle with constant speed.

D. An object first recedes, then comes towards you.

E. All of the above require a net force.

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Force and Motion Sample Problem

In a grocery store, you push a 12.5-kg shopping cart with a force of 14.0 N. If the cart starts at rest, how far does it move in 3.00 s?

$t_i = 0$	$t_f = 3.0s$
$x_i = 0$	$x_f = ?$
$(v_x)_i = 0$	$(v_x)_f = ?$
$a_x = ?$	$a_x = ?$

Use $x_f = x_i + (v_x)_i \Delta t + \frac{1}{2} a_x (\Delta t)^2$

but $a_x = ?$

$$(v_x)_f = (v_x)_i + a_x \Delta t$$
$$(v_x)_f^2 = (v_x)_i^2 + 2a_x \Delta x$$
$$x_f = x_i + (v_x)_i \Delta t + \tfrac{1}{2} a_x (\Delta t)^2$$

Use $F_x = ma_x$

$$\Rightarrow a_x = \frac{F_x}{m} = \frac{14.0N}{12.5kg} = 1.12m/s^2$$

$$x_f = 0 + 0(3.0s) + \tfrac{1}{2}(1.12m/s^2)(3.0s)^2$$

$$x_f = 5.04 \text{ m}$$

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