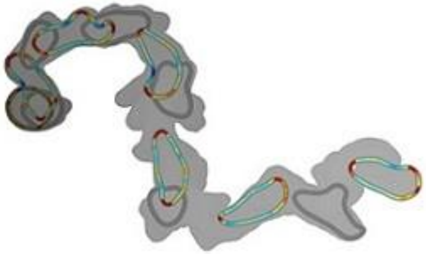
Physics 131- Fundamentals of Physics for Biologists I



Work

Kinetic Energy

Math: Dot Product

Quiz

10 min

Arpita Upadhaya research

In many of your science classes you talk about "energy."

What is it?

Write down:

one word or sentence or picture

one equation

Hold up your whiteboards

Whiteboard, TA & LA

Kinetic Energy and Work

Consider an object moving along a line feeling a single force *F*

When it moves a distance Δx, how much does its speed change?

$$a = F^{net} / m$$

$$\frac{\Delta v}{\Delta t} = \frac{F^{net}}{m}$$

$$\frac{\Delta v}{\Delta t}\Delta x = \frac{F^{net}}{m}\Delta x$$

$$\Delta v \frac{\Delta x}{\Delta t} = \frac{F^{net}\Delta x}{m}$$

$$\frac{\Delta x}{\Delta t}\Delta v = \frac{F^{net}\Delta x}{m}$$

$$\langle v \rangle \Delta v = \frac{F^{net}\Delta x}{m}$$

$$\frac{v_i + v_f}{2}(v_f - v_i) = \frac{F^{net}\Delta x}{m}$$

$$\tfrac{1}{2}(v_f^2 - v_i^2) = \frac{F^{net}\Delta x}{m}$$

$$\tfrac{1}{2}m(v_f^2 - v_i^2) = F^{net}\Delta x$$

Definitions:

Kinetic energy = $\tfrac{1}{2}mv^2$

Work done by a force *F* = $F\ \Delta x$

Result

$$\Delta(\tfrac{1}{2}mv^2) = F^{net}\ \Delta x$$

Dimensions and Units of Energy and Work

- $[1/2\ mv^2] = M\text{-}(L/T)^2 = ML^2/T^2$
- 1 kg-m^2 /s^2 = 1 N-m = 1 Joule
- Other units of energy are common (and will be discussed later)
  - – Calorie
  - – eV (electron Volt)

The diagram depicts two pucks on a frictionless table. Puck II is four times as massive as puck I. Starting from rest, the pucks are pushed across the table by two equal forces.

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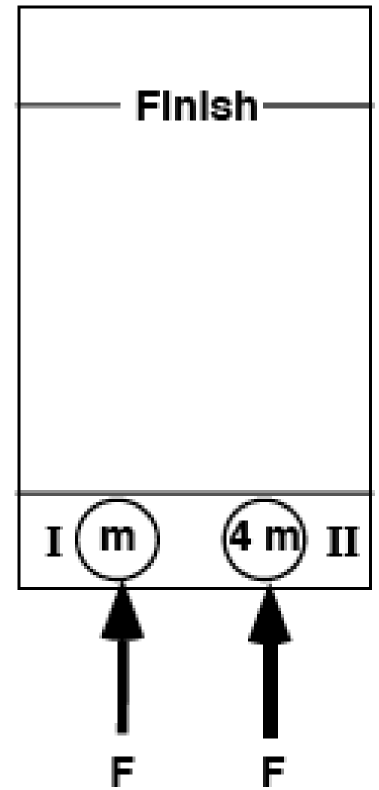

Which puck will have the greater **kinetic energy** upon reaching the finish line?

1. Puck I
2. Puck II
3. Both will have the same.
4. There is not enough information to decide.

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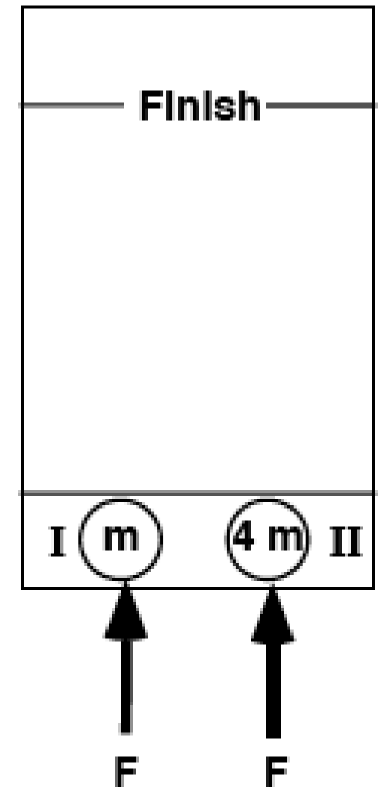
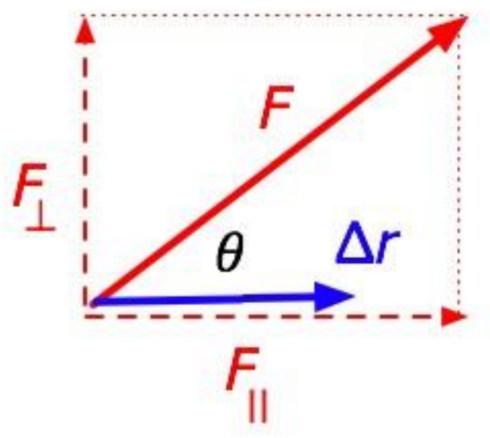


Which puck will have the greater **velocity** upon reaching the finish line?

1. Puck I
2. Puck II
3. Both will have the same.
4. There is not enough information to decide.

Work in another direction: The dot product

- Suppose we are moving along a line, but the force we are interested in in pointed in another direction? (How can this happen?)
- Only the part of the force in the direction of the motion counts to change the speed (energy).



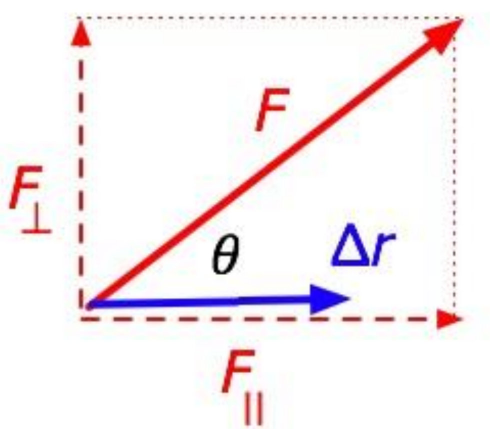
$$\text{Work} = F_{||}\,\Delta r = F\cos\theta\,\Delta r \equiv \vec{F}\cdot\Delta\vec{r}$$

Dot products in general

$$F_{\parallel}\,\Delta r \equiv \vec{F}\cdot\Delta\vec{r} \qquad\qquad \vec{F}\cdot\Delta\vec{r} = F\cos\theta\,\Delta r$$

In general, for any two vectors
that have an angle θ between them,
the dot product is defined to be $\vec{a}\times\vec{b} = ab\cos q$

$$\vec{a}\times\vec{b} = a_x b_x + a_y b_y$$



The dot product is a scalar.
Its value does not depend on the
coordinate system we select.

Each row in the following table pairs a force vector with a corresponding displacement resulting in work *W* being done.

In which of these rows is the work done zero?

	$\vec{F}$	$\Delta\vec{r}$
1.	→	←
2.	←	←
3.	↑	→
4.	↖	→
5.	↓	↖

6. None of the above

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