Energy

- Energy is a scalar quantity that is an important property of a system

- Energy can be exchanged (work), but never created/destroyed

- Types of energy:
  - Kinetic (motion)
  - Potential (stored by conservative force)
  - ??? (Seeming nonconservative forces, will address in later chapters)

Work

- Work is an *exchange* of energy by two objects due to the forces acting between them

- 1D, constant force: $W = F_x \Delta x$

- Any D, constant force: $W = \vec{F} \cdot \Delta \vec{r}$

- 1D, possible changing force: $W = \int_{x_1}^{x_2} F_x \, dx$

- General: $W = \int_{\vec{r}_1}^{\vec{r}_2} \vec{F} \cdot d\vec{r}$

?! Learn in Calc 3

Dot (Scalar) Product

- There is a way of multiplying vectors!

- Dot product gives you component of first vector in direction of second (times magnitude of second)

- Formulas:
$$\vec{A} \cdot \vec{B} = A B \cos \theta_{AB}$$
$$\vec{A} \cdot \vec{B} = A_x B_x + A_y B_y + A_z B_z$$

- Class ex: Find the dot product of the force vector $\vec{F} = F_x \hat{i} + F_y \hat{j} + F_z \hat{k}$ with the vector $\hat{j}$

Kinetic Energy

- Moving objects have a stored energy given by

$$K = \frac{1}{2} m v^2$$

  – Scalar, doesn't depend on direction of velocity!

- This is the work done to accelerate an object from rest to speed v by a net force

Potential Energy

- A force is "conservative" if it always does the same work between two points, no matter what the path/timing is

  - Ex: gravity, springs

- For conservative forces, can define potential energy so that difference between two points is opposite work done *by* the force $\Delta U = -W$

- Useful because we don't have to calculate work directly if we know PE formula!

  - Springs: $U = \dfrac{1}{2} k x^2$