Traditional: 05-01
Themed: 11-01

Physics Work, Energy & Power

Energy definitions

- **Work** – Applying a force on an object to give it more energy (force x distance)
- **Joule** – Physics unit of energy = 1 newton of force x 1 meter of distance
- **Kinetic energy** – energy of motion: KE = ½ mv^2
- **Gravitational potential energy** – energy of position (GPE, or often called just PE): GPE = mgh
- **Mechanical energy** – called "ME", the sum of KE and GPE
- **Potential energy** – stored energy of many varieties including GPE, elastic energy, chemical energy, etc.
- **Internal energy** – Energy of heat (the "wasteland" of energy), usually from friction
- **Deformation energy** – Energy that goes into bending, breaking, etc. an object (car crash, smashed clay ball, etc.)
- **Conservation of energy** – energy cannot be created nor destroyed, just converted between different forms
- **Pendulum** – an efficient mechanical device in which KE and PE constantly exchange
- **Perpetual motion machine** – An ideal (frictionless) machine in which no energy is ever converted to heat

More detail: What are work and energy?

- Circular definitions:
  - Energy is the capacity to do work & work is something that increases/decreases the energy by applying a force over a distance
  - Work can be negative or positive: it can increase or decrease energy of an object
  - Work is a scalar, not a vector (we don't define any direction for work)
- What does this mean exactly? Examples….
  - A cart standing still has no energy
  - Push it across the floor (apply a force over a distance) and you give it KE
  - Push it up a hill and you give it GPE (if you let it go, it **rolls** back down the hill)

Is this work or isn't it?
Energy changed?
Force in direction of displacement?

Work or not?
Chris holds a large weight above his head for a really long time
Virginia puts away plates in a high cabinet
Peter throws a bounce pass
Gretta jumps into the air
Allie spends two hours writing a paper (What a waste! Physics is sooo much better!)
Nick pushes a cart along level floor at constant speed
Alex climbs stairs at constant speed
Grace slows down her car by applying the brakes
Henry spends hours researching a trip to France
Hart hits a serve horizontally
A physics student launches a bowling ball at high speed down a lane (almost getting a 300 I might add)

How is energy useful?

- It lets us predict things and explain the world around us
  - If I lift a 5 kg bowling ball 2 m in the air, I can predict how fast it will be going when it comes back down
  - If it rolls over some silly putty and smashes it, I can measure how much energy went into smashing, by knowing how much energy the ball lost
  - I can drop a 200 g book to the floor and see how much energy it will impart on the floor AND find how fast it's going **without** using NIFTY

Examples (don't forget SI units!)

- $KE = \frac{1}{2} mv^2$
  - A 100 kg linebacker runs 40 m in 5.1 seconds, how much KE does he have? (assume constant speed)
- GPE = mgh
  - A 55 kg cheerleader is lifted 3.0 m into the air. How much gravitational potential energy does she have?
- ME = KE + GPE
  - A 600 kg rollercoaster going 12 m/s is still 6.0 m above the low point on the track. How much mechanical energy does it possess?
- Conservation of Energy:

Energy before = Energy after

  - Our cheerleader is let go and drops to 1 m where she is caught. Just before impact, how many joules of PE will be converted to KE? How fast will she be going?
- You push on a 150 g pendulum hard enough to get it moving 3 m/s at it's lowest point. How high above its low point is it when it's moving only 1 m/s?

Relationships

- $KE = \frac{1}{2} mv^2$
  - Doubling mass doubles KE
  - Doubling speed quadruples KE (square of speed)
- GPE = mgh
  - Doubling mass doubles GPE
  - Doubling height doubles GPE
- ME = KE + GPE
  - If assumed “frictionless”, however much KE is lost is PE gained
- Conservation of Energy:

Energy before = Energy after

  - Less energy after means some energy converted to heat (“internal energy”)
  - Heat energy generally cannot be recovered for useful work again