Work and Power

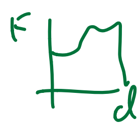
Definition of Work:

$W = \Delta E$

$= Fd\cos\theta$

$= mad\cos\theta$

= Area under graph



Definition of Power:

$P = \frac{\text{Work}}{\text{time}} \rightarrow \frac{J}{s} = W$

The average speed of a MLB fastball is 42m/s. To get a home run (clear the park) you need to hit the ball with at least a velocity of 30.6m/s. How much work is done by the batter? Mass of a base ball = .15kg.

$W = \Delta E = \Delta E_p + \Delta E_k$

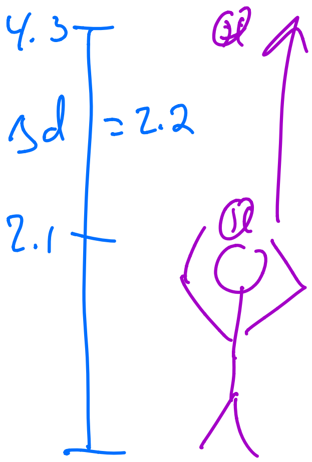
$= 0 + \frac{m v_f^2}{2} - \frac{m v_i^2}{2}$

$= \frac{.15(30.6)^2}{2} - \frac{.15(-42)^2}{2}$

$$= \frac{.15}{2}(30.6^2 - 42^2)$$

$$= -62.1\ J$$

When Kyle plays volleyball he does not spike the ball every play. Sometimes he is a team player and sets up his team mate so that they can spike the ball too. If Kyle sets up the ball to a height of 4.3m and a volleyball weighs .275kg. How much work has Kyle done if he hit the ball from a height of 2.1m?



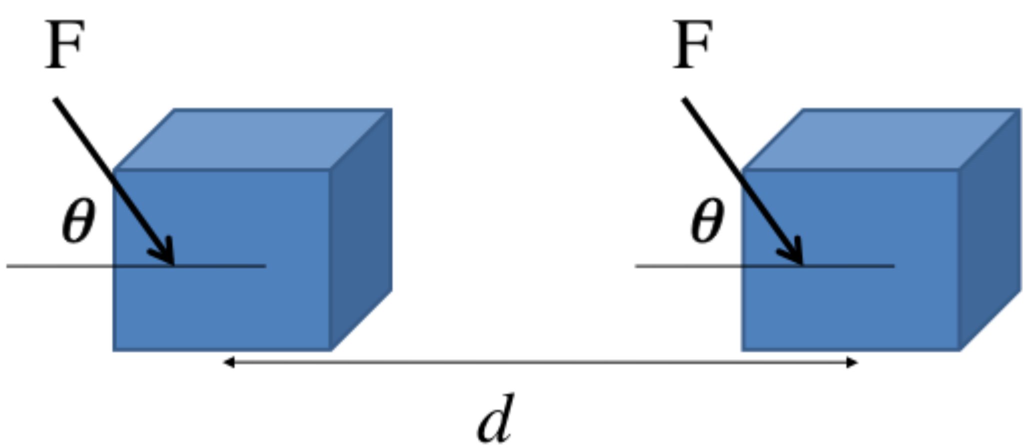
$$W = \Delta E = mg\Delta h$$

$$= .275(9.81)(2.2)$$

$$= 5.9\ J$$

That was too easy. Let's do a tricky one.

The only force we care about is the force that is causing the ΔE.



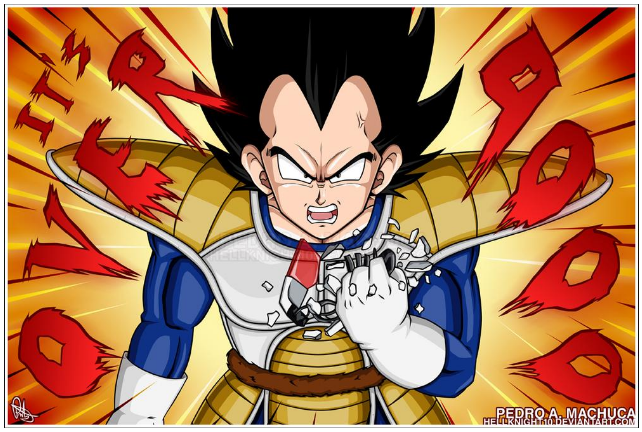
If the force is 52N and θ is 60° and the distance is 12m. What is the work done?

$$W = Fd\cos\theta$$

$$= mad\cos\theta$$

$$= \frac{52(12)}{2} = 52(6) = 312\ J$$

MORE POWER NEEDED



$$Power = \frac{Work}{Time} = \frac{J}{s} = Watt = W$$

One common measurement of power is the horsepower (hp). It is good to note that 1hp ≈750W. Also important is that one horse has roughly 15hp…

A 100W lightbulb operates for one hour. How much work was done?

$$P = \frac{W}{t}$$

$$100 = \frac{W}{3600}$$

$$3600(100) = W$$

$$360000 = W$$

$$360\ kJ = W$$

Abbey is pulling Alley in a wagon. She pulls her for 10m. She pulls at an angle of 32° and applies a force of 210N for 20s. What power does Abbey produce?

$d = 10$

$\theta = 32$

$F = 210$

$t = 20$

$P = ?$

$$P = \frac{W}{t} = \frac{Fd\cos\theta}{t}$$

$$= \frac{(210)(10)\cos(32)}{20}$$

$$= 89\ W$$

In Kelowna we pay at most $0.15 per kW*hr.
Does your Mom tell you to turn off the lights?
Let’s run a 60W (old style) light bulb for 8 hours.

$60W \rightarrow .06\ kW$ for 8 hours

kW·hr

$$= .06(8)(.15)$$

$= .07$

Efficiency:

This is how much of the energy that you put into a system is the energy that you want. Some will be wasted.

$$Eff = \frac{Useful\ Out}{Total\ In} x100\%$$

Look at the total amount of energy that you put into a system, and decide how much of that is what you want.

A 60W light bulb produces 15W of light energy. What is its efficiency?

$$\frac{15}{60} 100\% = 25\%$$

An Easy Bake oven uses this same light bulb to make cupcakes. What is its efficiency?

$$\frac{45}{60} x 100\% = 75\%$$

Chris drops a 5kg watermelon off of a tall building (20m) and it strikes the ground with a velocity of 15.0m/s. How much energy is lost as heat (E_H)? And, what is the efficiency of the fall?

$$E_{po} + E_{ko} = E_{pf} + E_{kf} + E_H$$

$$5(9.81)(20) = \frac{5(15)^2}{2} + E_H$$

$mgh = E_p$

$\frac{mv^2}{2} = E_k$

$$5(9.81)(20) - \frac{5(15)^2}{2} = E_H$$

$$419J = E_H$$

$$\frac{\text{want}}{\text{total}} = \frac{E_k(\text{after})}{E_p(\text{before})} \times 100\% = 57\%$$