Work and Energy

What’s the relationship?

Work

- In order for **work** to be done the following must occur:
- There must be a force
- There must be a displacement
- We only consider the force that is parallel to the distance!

Mini Lab...

- Attach a spring Balance to a 1 kg mass. Pull the mass along a table for a distance of 1m while the balance is almost horizontal, repeat this and record the force required

- Now repeat this holding the balance at an angle of about 30 degrees to the table and pull for 1m, measure the force for at least two trials, what do you notice? Compare the values of Work Done!

Work...

Basic equations is

$$W = F \times d_{||}$$

But what if the force isn't actually parallel? Can work still be done?

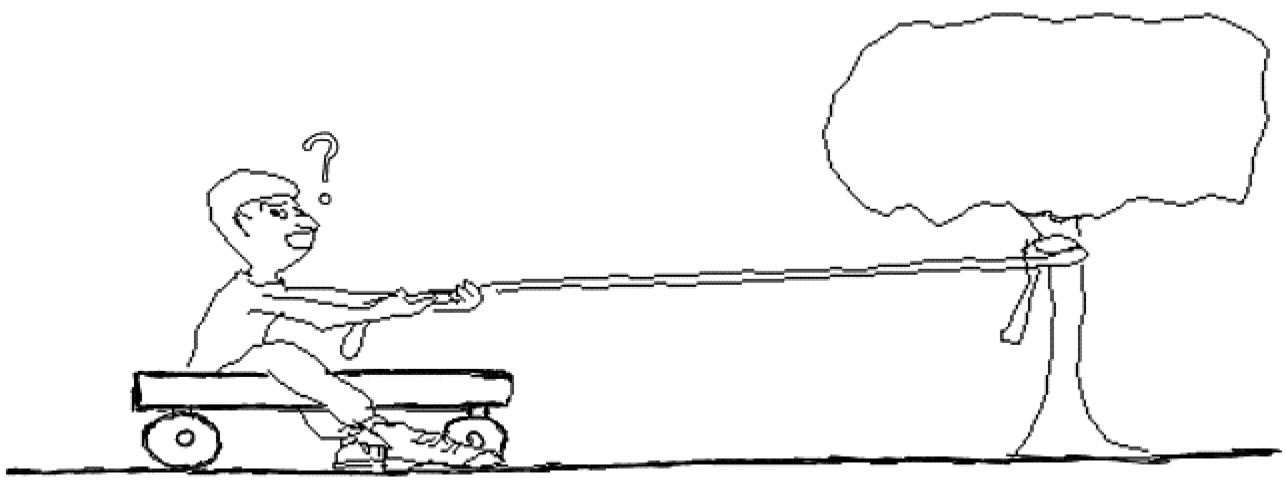
Yes but we need to consider the forces components!!

This gives us a better equation!

$$\text{Work} = F \cos \theta \times d$$

Is Work Done?

When he pulls on the tree, does the tree pull back? Does the tree do any work?



If he stands still, does he do any work?

Worked examples...

- A student lifts a box that weighs 185N. The box is lifted 0.800 m. How much work is done?
- W = F x d

  =(185N)(0.800m)

  = 148 N.m

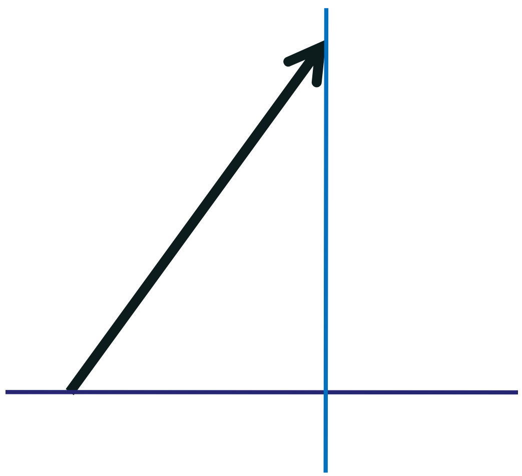
  = 148 J (joules)

Note:
The units used for work should seem familiar?

Where else is the joule used and what conclusion does this help you to reach?

Work example #2

- A sailor pulls a boat along a dock using a rope. If the rope is at a 60.0º angle with the horizontal and he pulls with a force of 255N, how much work is done to pull the boat 30.0 m?



$$W = Fd \cos \theta$$

$$= (255)(30.0)(\cos 60.0^\circ)$$

$$= 3.83 \times 10^3 \text{ J}$$

Power...

- So far we have ignored the time taken to complete the work done...
- The work remains the same no matter how long the task takes but the **Power** is different!
- Power is the rate of doing work. Or else it can be said that *power is the rate at which energy is transferred*

Power

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

Power is measured in ***Watts***

One Watt is one joule of energy transferred in one second

A Watt is a small unit of power so we often use kilowatts (kW)

1 kW = 1000 Watts

In many parts of the world the power of automobiles is measured in "Horsepower". This was a unit of power established by James Watt so he could describe to others the relative power of his recently developed steam engine. Since the horsepower and the watt are both units of the same thing, power, they can be related to one another. **(One horsepower equals 746 watts.)**

Your Turn...

- Do the questions provided in the work sheet
- Review your text book
- Do the practice questions Page 177 and 179

Gravitational Potential Energy

- The energy of position,
- EP = mgh
- Thus it needs a height, mass and gravity!
- Where is it zero?
- How does it gain energy just because of its position?

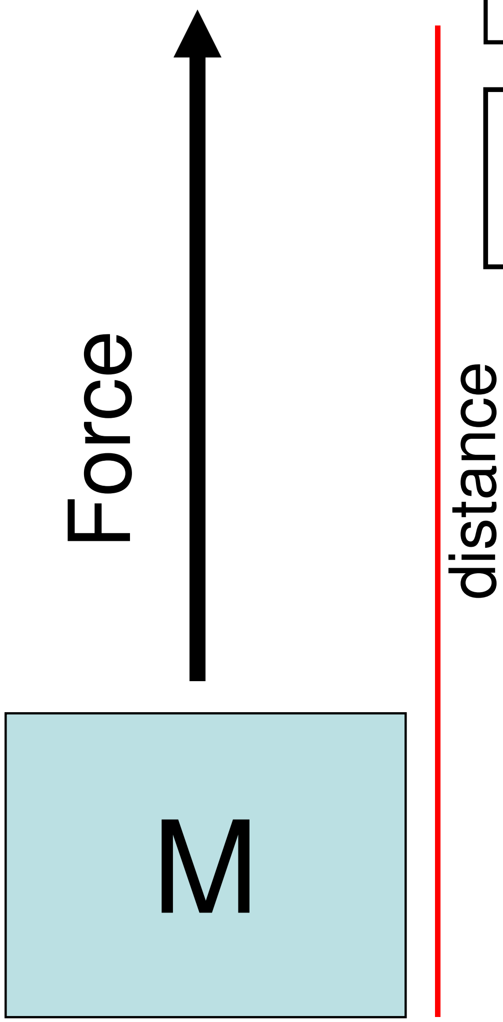
Kinetic Energy

- Energy of Motion
- $EK = \frac{1}{2} mv^2$
- Thus it needs a velocity and a mass!
- When is it zero?
- How does it gain energy just because it moves?

Work done = F Cosθ x d

The object now has potential energy, what is the value of its EP?

What happened to the Potential Energy as it fell?



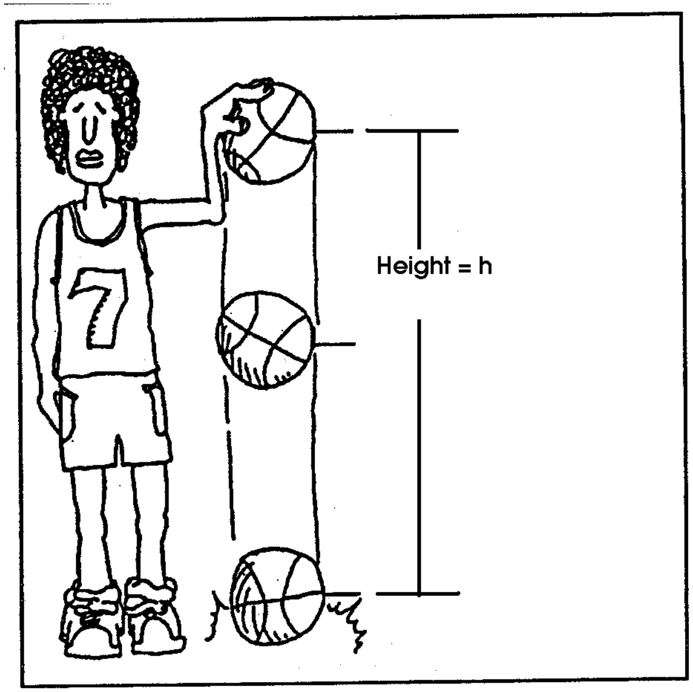
The law of conservation of energy says that energy is always conserved so then we can say that

$$Work_{done} = EP_{gained} = Ek_{at\ the\ bottom}$$

Or more importantly energy change = 0

Need proof?

- Consider a basket ball player lifting a basket ball to a height of h, he does work, lifting with force to a height h, ie



$$\text{work} = F \times d$$

$$w = ma \bullet d, \text{ but we going up } \therefore a = g$$

$$\therefore w = mgd$$

$$w = mgh, \quad \text{hmm!}$$

We know that EP = mgh!

So if the basketball has a mass of 600.0g and is raised to a height of 1.83 m, how much work is done?

$$W = Fd$$

$$W = mgd$$

$$W = (0.6g)(9.80)(1.83m)$$

$$W = 10.8\text{J}$$

So how much potential energy did it gain?

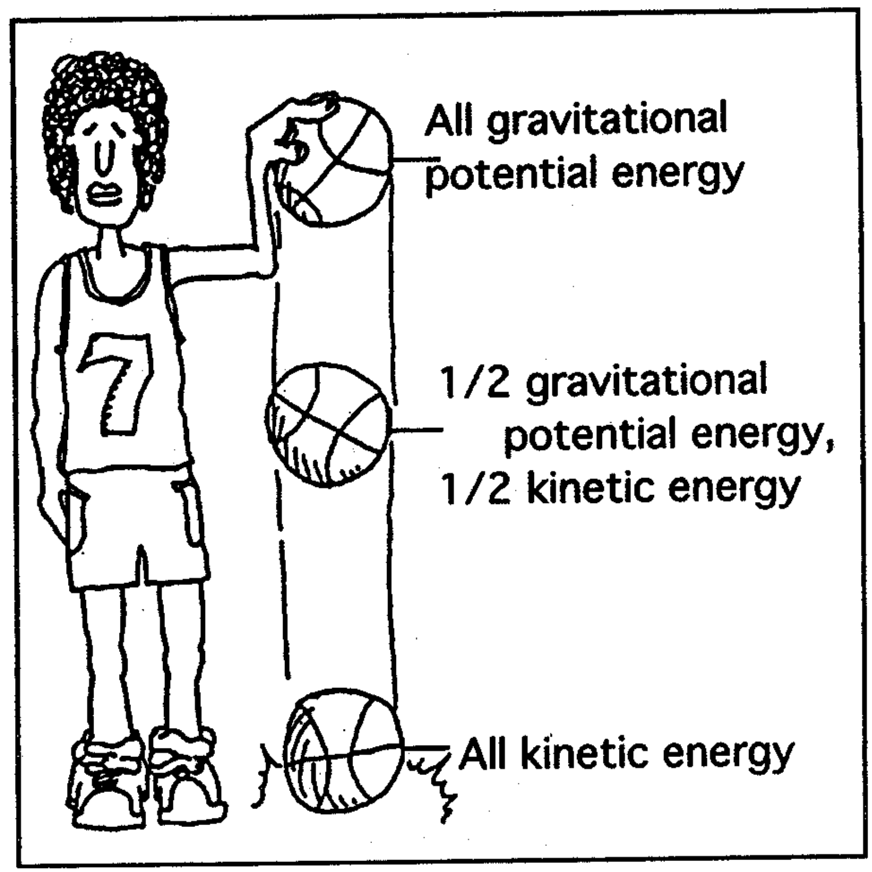
$$\text{Work} = \Delta\text{Energy}$$

$$\therefore \text{Work} = \text{EP} = mgh = 10.8\text{J}$$

More proof

Consider what happens as the ball is allowed to fall under the inluence of gravity

Yes but …can we prove this mathematically?



And finally…

ball accelerates

$\Rightarrow \text{a} = \text{g}$

but initial velocity = 0 m/s

$$\text{v}_\text{f}^{\,2} = v_i^{\,2} + 2ad$$

$$\text{v}_\text{f}^{\,2} = 2ad$$

which we can write as

$$\text{v}_\text{f}^{\,2} = 2gh$$

$$\therefore gh = \frac{\text{v}_\text{f}^{\,2}}{2}$$

$$mgh = m\frac{\text{v}_\text{f}^{\,2}}{2}$$

$$mgh = \tfrac{1}{2} m v_\text{f}^{\,2}$$

But we know that $\text{EK} = \tfrac{1}{2} m v_\text{f}^{\,2}$

Kinetic Energy

- What is the Kinetic energy of the basketball just before it hits the ground?

$$W = EP = EK$$

$$\therefore EK = 10.8\text{J}$$

- What is its velocity just before it hits the ground?

$$EK = \frac{1}{2}mv^2 = \frac{1}{2}(0.6kg)(v)^2$$

and so the stunning conclusion is…

EP + EK = Total Mechanical Energy

And because of Conservation of Energy

EPi + EKi = EPf + EKf

Practice Required

- Page 186 Q 1 and 2
- Page 187 Q 1 and 2
- Page 189 Q 1- 6
- Page 194 Q 1 - 3