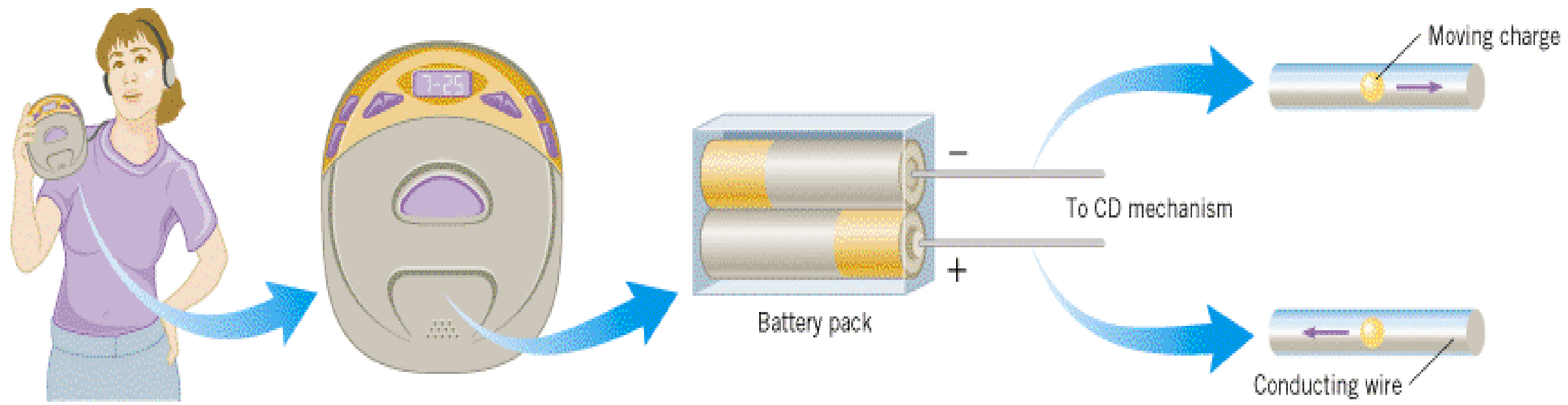
# Term 3

Energy Transfer and Potential Difference

# CD- Player

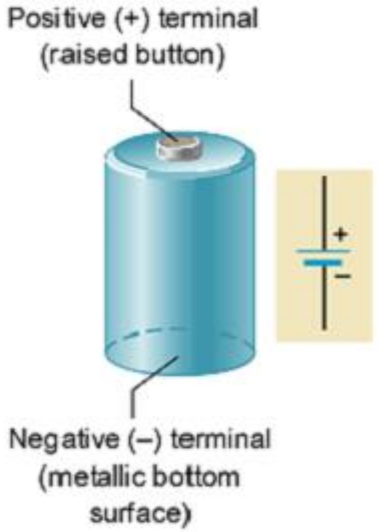


Moving charge
–
To CD mechanism
+
Battery pack
Conducting wire

# Electric potential

- What does it mean when it says “1.5 Volts” on the battery?


- The electric potential difference between the ends is 1.5 Volts




# *Electromotive Force (emf)*

The energy needed to run a CD player, for instance, comes from batteries.

Within a battery, a chemical reaction occurs that transfers electrons from one terminal (leaving it positively charged) to another terminal (leaving it negatively charged).

Because of the positive and negative charges on the battery terminals, an electric potential difference exists between them.

The maximum potential difference is called the ***electromotive force* (emf)*** of the battery.

The electric potential difference is also known as the voltage, V.

The SI unit for voltage is the volt, after Alessandro Volta (1745-1827) who invented the electric battery. 1 volt = 1 J/C.

# Emf’s or Voltages of Common Batteries

- Car battery = 12 V
- AAA, AA, C, D = 1.5 V
- 9-volt battery = 9 V
- Button Battery = 3 V

# Electric potential

230 V

1.5 V


100,000 V

So what is a volt?

# Electric potential

- The electric potential difference $\Delta V$ in volts between two points is the work in Joules needed to move 1 C of charge between those points

$$\boxed{W = q \times \Delta V}$$

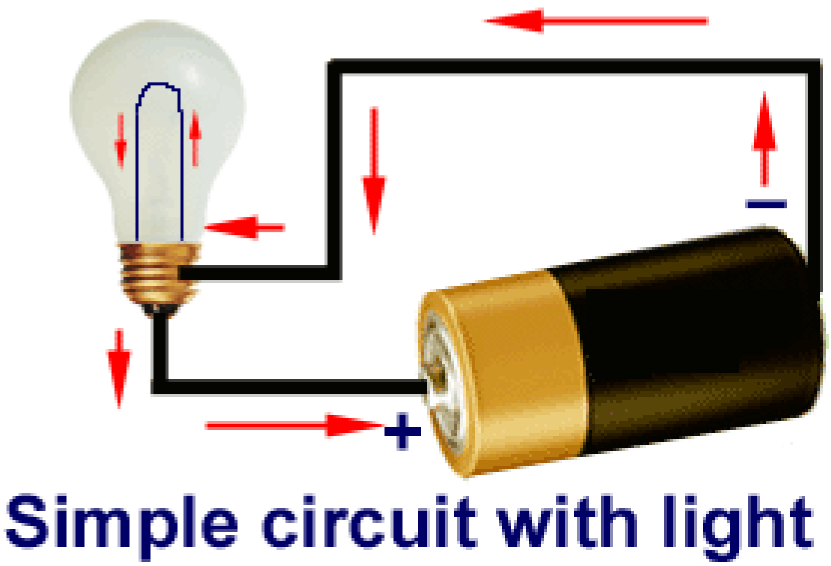
W = work done [in J]
q = charge [in C]
ΔV = potential difference [in V]

- $\Delta V$ is measured in volts [V] : 1 V = 1 J/C

# Electric potential

- The electric potential difference $\Delta V$ in volts between two points is the work in Joules needed to move 1 C of charge between those points

$$W = q \times \Delta V$$



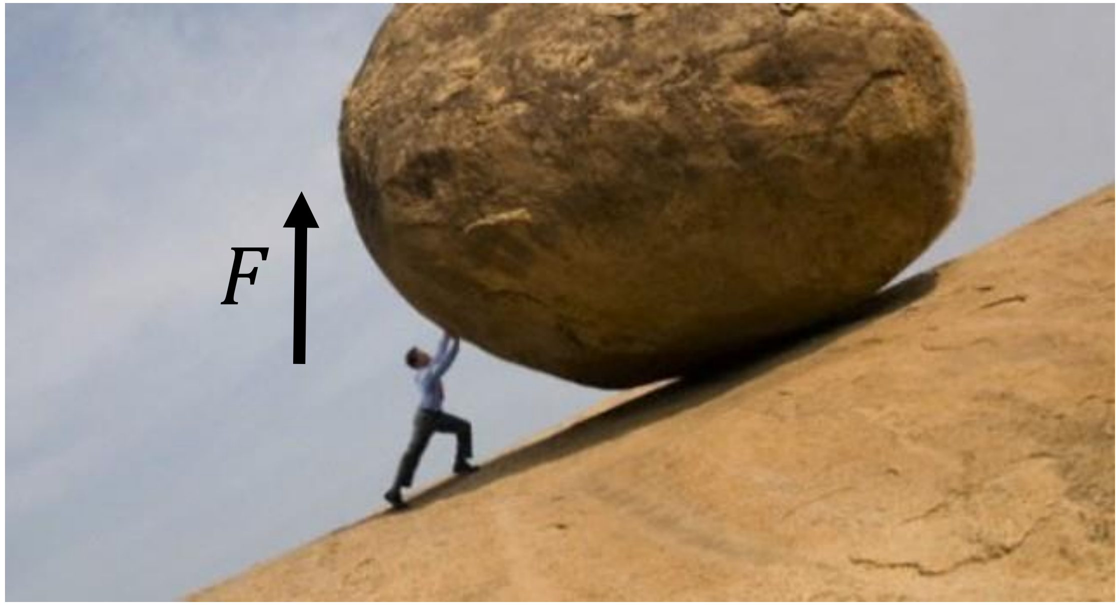

The 1.5 V battery does 1.5 J of work for every 1 C of charge flowing round the circuit

# Potential energy

- Potential energy is the energy stored in a system (when work is done against a force)

- e.g. force of gravity …

$$F = mg$$




Work = Force x Distance

$h$

$$W = F \times h$$

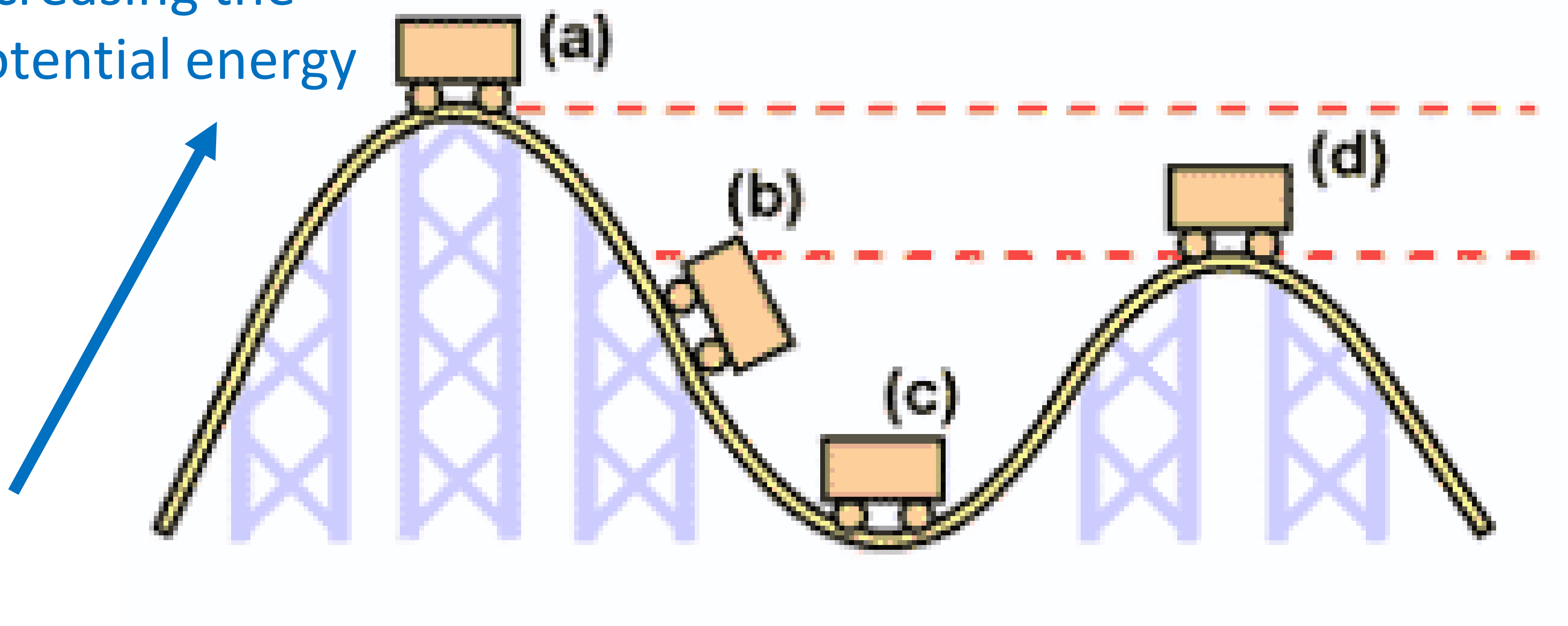
$$= mgh$$

$$= mgh$$

# Potential energy

- Potential energy may be released and converted into other forms (such as kinetic energy)

Work is done, increasing the potential energy



# Potential energy

- Potential energy difference is the only thing that matters – not the reference (or zero) level

- For example, applying conservation of energy to a mechanics problem:

Final energy = Initial energy

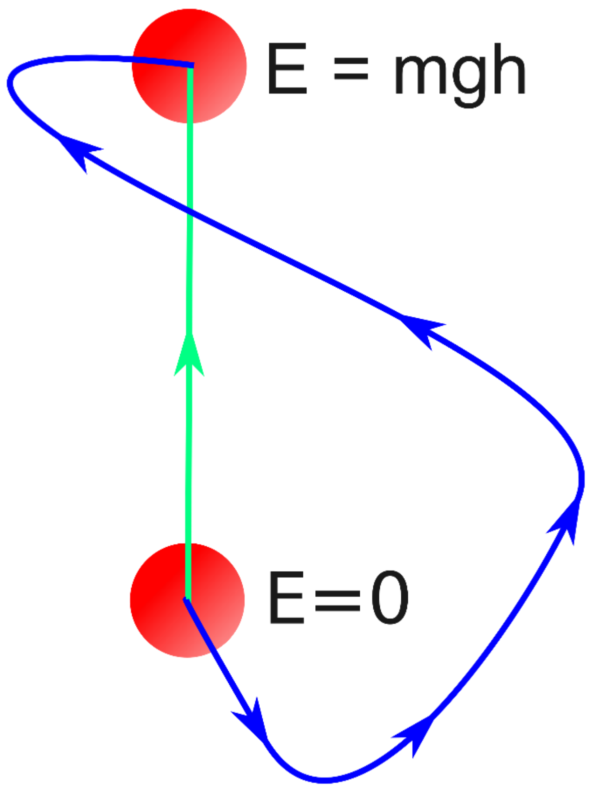
$$KE_{final} + PE_{final} = KE_{initial} + PE_{initial}$$

$$KE_{final} = KE_{initial} + (PE_{initial} - PE_{final})$$

Difference in potential energy

# Potential energy

- Potential energy difference doesn't depend on the path – only on the two points A and B




# The Process

In the circuit, each electron gains electrical potential energy as it moves through the battery. Each electron then transports this energy to the lamp.

As they move through the lamp filament, the electrons collide with the filament ions and so transfer energy to them.

As each coulomb moves through the battery it 'picks up' a fixed amount of electrical potential energy. The coulomb 'drops off' this energy as it passes through the lamp. The coulombs then return to the battery to collect more energy.

# Energy Transfer

The coulombs entering the lamp have electrical potential energy; those leaving have very little potential energy.

There is a **potential difference** (or p.d.) ***across*** the lamp, because the potential energy of each coulomb has been transferred to heat and light within the lamp.

***The p.d. between two points is the electrical potential energy transferred to other forms, per coulomb of charge that passes between the two points.***

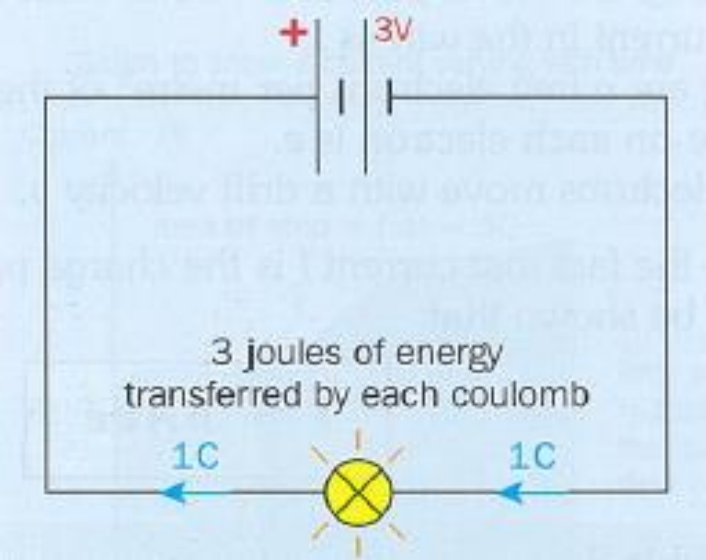
# Energy Transfer

The greater the p.d., the more energy transferred per coulomb.

$$\text{p.d., } V \text{ (volts)} = \frac{\text{energy transferred, } W \text{ (joules)}}{\text{charge, } Q \text{ (coulombs)}}$$

$$V = \frac{W}{Q}$$

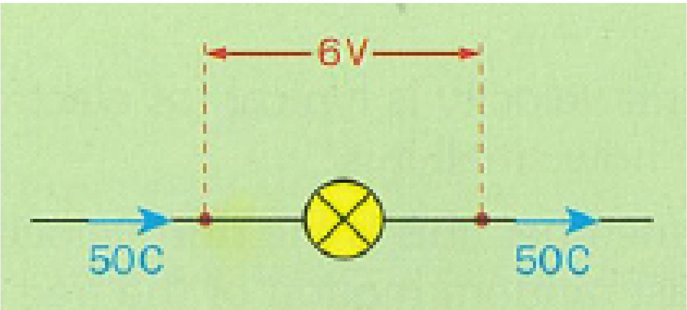
$$W = Q\,V$$




*If the p.d. is 1 volt, then 1 joule of electrical energy is transferred for each coulomb of charge.*

# Example

In the circuit shown, the p.d. across the lamp is 6.0 V.
If 50 coulombs of charge pass through the lamp,
how much electrical energy is transferred to heat and light?




$$\boldsymbol{W = Q\,V}$$

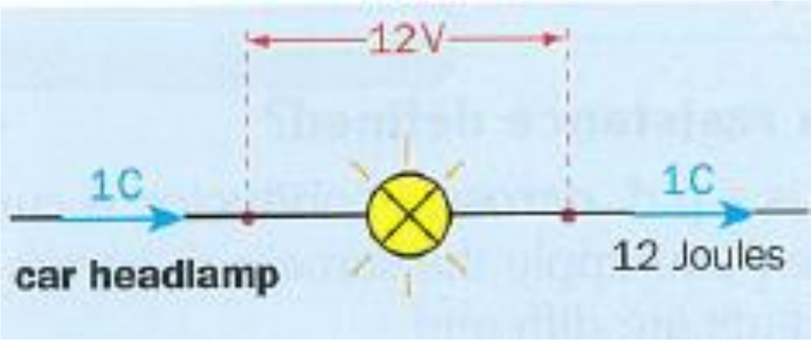
$$\therefore \quad W = 50\text{ C} \times 6.0\text{ V} = \underline{300\text{ J}}$$

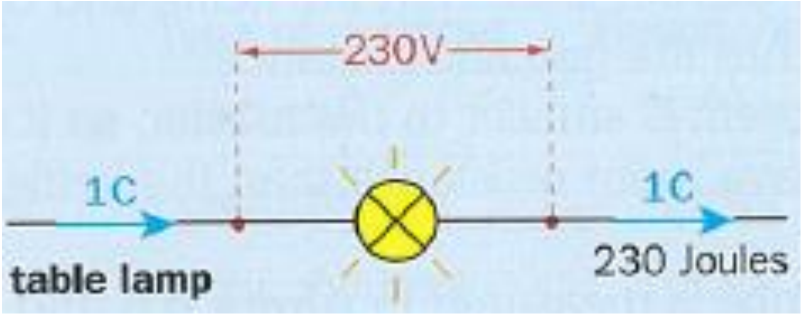
# Measuring PD

The p.d. across the car head-lamp is 12 volts

When 1 coulomb passes through the head-lamp 12 joules of electrical energy are transferred to heat and light.

The p.d. across a table lamp is 230 volts. So 230 J of energy are transferred when 1 coulomb passes through this lamp.



# Is the table lamp brighter than the head-lamp?

Energy transferred, $W$ (joules) = charge, $Q$ (coulombs) × p.d., $V$ (volts)

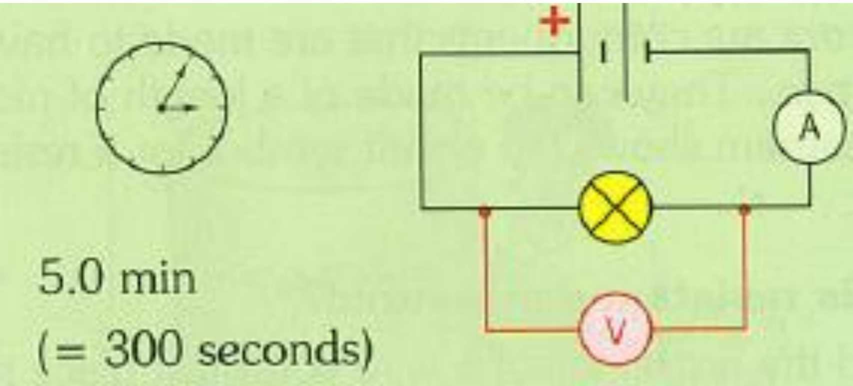
$$Q = I\,t$$

**Energy, $W$ (joules) = current, $I$ (amps) × time, $t$ (seconds) × p.d., $V$ (volts)**

$$W = I\,t\,V$$

$$W = V\,I\,t$$

In the circuit shown the voltmeter reads 10 V and the ammeter records a current of 0.20 A. How much energy is transferred to heat and light in the lamp in 5.0 minutes?




$W = V\,I\,t$ (remember that $t$ must be in seconds)

$\therefore$ W = 10 V × 0.20 A × 300 s = 600 J

# Example

*Calculate the voltage of a battery if it supplies 300 joules of energy to 50C of charge.*

**voltage** = **energy** ÷ **charge**

$$= \frac{300\ J}{50\ C}$$

**battery voltage = 6V**

Complete: **Answers**

| ***Voltage*** | ***Energy*** | ***Charge*** |
|---|---|---|
| 12V | 480J | **40C** |
| **20V** | 500J | 25C |
| 6V | **120J** | 20C |
| 230V | 69kJ | **300C** |