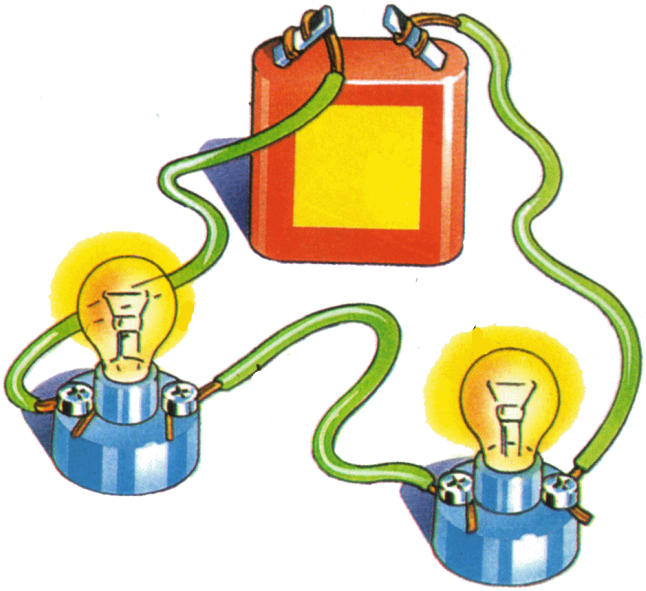
National 5

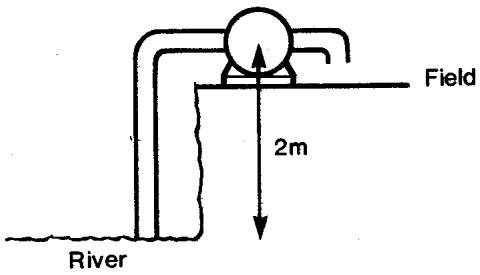
Energy and Electricity Homework



Homework 1

1. Peter and John work at a supermarket. They are responsible for collecting trolleys from the trolley parks in the car park and returning them to the store.
   (a) What type of energy does a moving trolley have?
   (b) Peter collects trolleys from the furthest trolley park. He has to pull them 150 m back to the store and collects 10 trolleys at a time. If Peter pulls the 10 trolleys together with an average force of 350 N calculate how much work he does in one journey.
   (c) John does not have so far to walk so he collects 20 trolleys at a time. He pulls his trolleys with an average force of 525 N and covers 100 m each journey. Calculate how much work he does in one trip.
   (d) Each boy has to return 80 trolleys to the store before finishing their shift.
      (i) Calculate how many journeys each boy has to make.
      (ii) Show by calculation who does the most work.

2. An irrigation pump lifts 10kg of water from a river on to a field lying 2m above it.
   (a) What type of energy is the water gaining?
   (b) What is the minimum amount of energy needed to do this?



3. A vehicle, mass 1800 kg, travels at a 20m against a constant air resistance force of 400 N.
   Calculate the work done by the car.

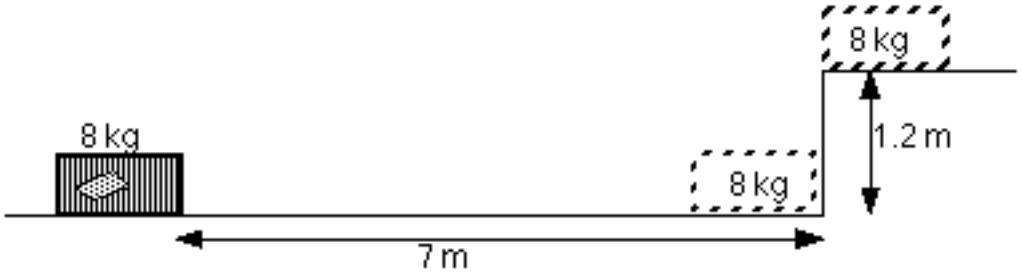
4. Which of the following could be the unit of potential energy?
   A N m
   B N m/s
   C kg m/s
   D N/kg
   E kg m^2/s^2

5. Which of the following show two physics quantities that have the same unit?
   A Potential energy and work done
   B Momentum and kinetic energy
   C Potential energy and momentum
   D Force and work done
   E Force and mass

Homework 2

1. An apple with a mass of 100g is dropped from the top of the Eiffel Tower which has a height of 300m
   (a) How much potential energy would it have at the top of the tower?
   (b) How much kinetic energy would it have just before hitting the ground, assuming no energy is lost?
   (c) What will be its velocity as it hits the ground?

2. A box of mass 8 kg is dragged 7m along a floor in a warehouse against a constant frictional force of 20 N. It is then lifted onto a shelf which is 1.2 m above the floor.



   (*a*) Calculate the total energy required for this operation.

3. During the Winter Olympics a ski jumper speeds down a slope to the jump. The mass of the skier is 75 kg and the height of the slope is 30 m.
   (a) Calculate the potential energy lost by the jumper as he skis down the slope.
   (b) What is the maximum speed that this skier could reach at the bottom of the slope?
   (c) The actual speed which he reaches is 20 ms^{-1}. If the slope is 100 m long calculate the force of friction which was acting on the skier while he travelled down the slope.

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Homework 2 (Continued)

4. After retrieving his 46 g golf ball from a bush, a golfer takes a penalty drop by holding the ball at arm's length and allowing it to drop a height of 1.5 m to the ground.

   (a) What is the gravitational potential energy of the ball just before it is dropped?
   (b) What is the speed of the ball when it hits the ground?
   (c) What is the speed of the ball when it is 0.75 metres above the ground?

5. An 85 kg skydiver jumps out of an aeroplane which is at a height of 3800 metres. The parachute is opened at a height of 1300 metres above the ground.

   (a) What is the speed of the skydiver just before the parachute is opened?
   (b) In reality, the speed of the skydiver is 55 m/s at this point. Explain the difference in the speed calculated in part (a) and the actual speed of the speed diver.

6. A roller coaster car has a mass of 5000 kg and is travelling with a speed of 18 m/s as it enters a loop which has a height of 12 metres.

   (a) What is the kinetic energy of the roller coaster car at the moment it reaches the loop?
   (b) What is the gravitational potential energy of the roller coaster car at the top of the loop?
   (c) What is the kinetic energy of the roller coaster car at the top of the loop?
   (d) What is the speed of the roller coaster car at the top of the loop?

Homework 3

1. Vehicle manufacturers charge the body of cars and use charged paint to give cars their final colour. By using your knowledge of electrostatics:
   a) How does this result in an even coat of paint over the whole surface of the car.
   b) Explain how this limits the amount of paint that is wasted.

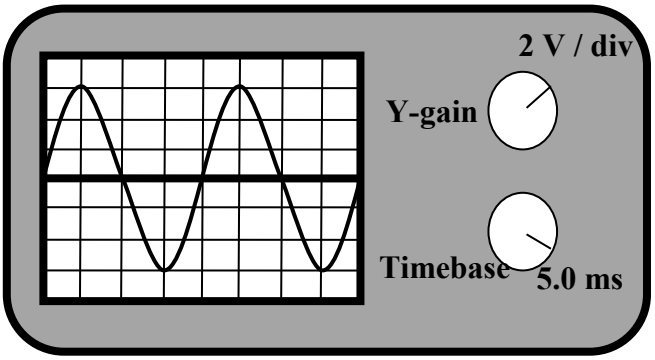
2. When a kettle is switched on, there is a current of 10 A in the element. The kettle is switched on for 2 minutes. How much charge flows through the heating element in this time?

3. The total charge that will pass through a vacuum cleaner is 600C when it is switched on for 5 minutes. Calculate the current from the mains supply.

4. Calculate the time taken for a current of 2.0 A to transfer 500C of charge through a lamp.

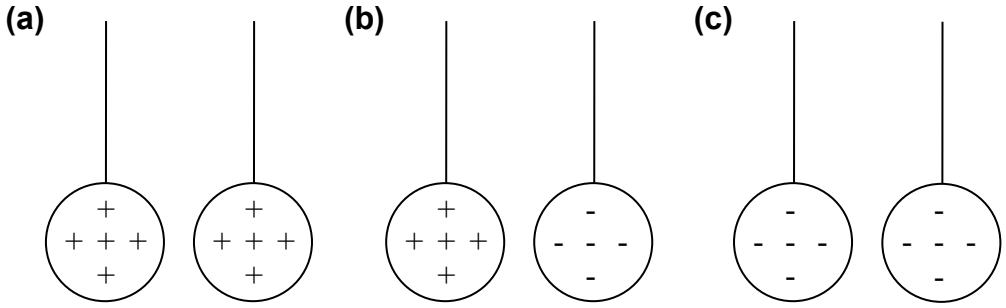
5. a) Explain what is meant by the term ‘electric current’.
   b) Explain the difference between an a.c. and a d.c. voltage supply
   c) Give an example of a d.c. voltage supply and an a.c. voltage supply.

6. a) Does the oscilloscope trace represent an alternating current or a direct current.
   b) For the oscilloscope trace, calculate the:
      i) Peak voltage
      ii) Frequency

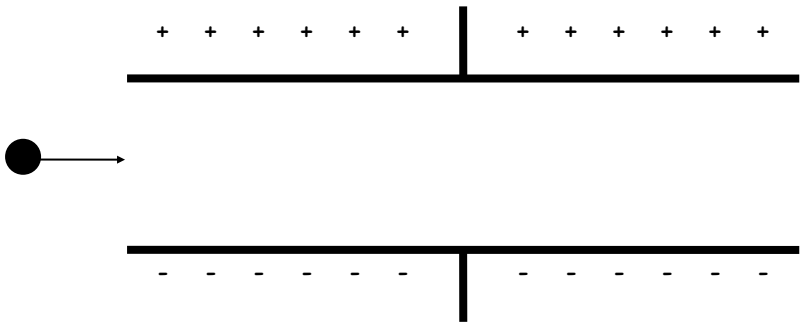


Homework 4

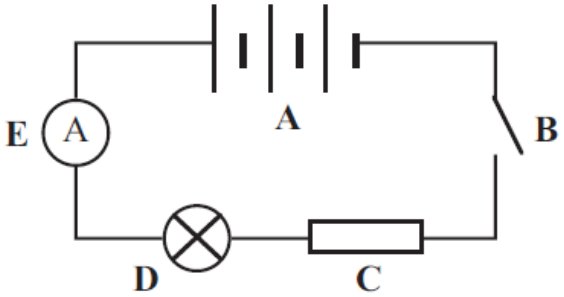
1. In a classroom experiment, two metallised polystyrene spheres are hung from a thread, as shown below. Copy the diagrams below and use arrows to show the direction of movement of each sphere.



2. Copy this diagram and add the paths of the following particles entering at right angles to the electric field:
   a) Electron b) Proton c) Neutron



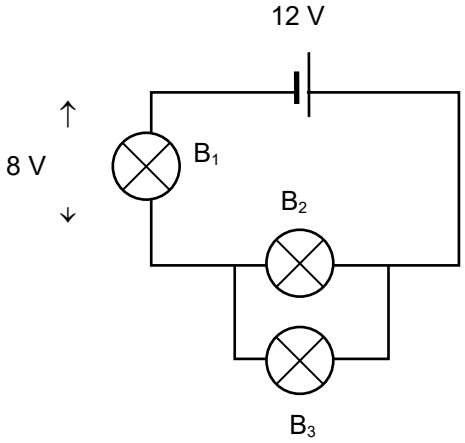
3. In the circuit below, name the components labelled A, B, C, D and E.



4. Describe the function of the following components:
   a) Variable resistor
   b) Thermistor
   c) Speaker
   d) PV (solar) cell
   e) Fuse

Homework 5

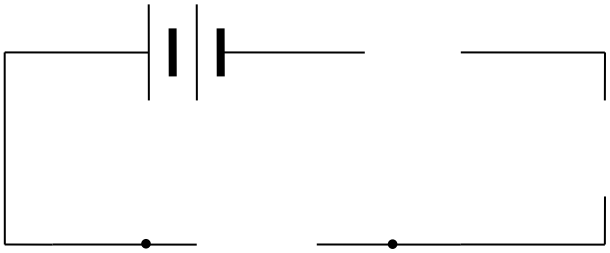
1. Bulbs B_1, B_2 and B_3 are all identical. What is the voltage across bulb B_2 and bulb B_3?



2. Two pupils are given an unmarked resistor, a variable resistor, two 1.5 V cells, an ammeter and a voltmeter. Their task is to find the resistance of the resistor.

(a) Copy and complete this circuit diagram, using all the components, to show the circuit the pupils should build.

(b) Explain how they should use the circuit to complete their task.



(c) The readings they obtain are as follows:

Current (mA)	Voltage (V)
0	0.0
10	0.5
20	1.0
30	1.5
40	2.0
50	2.5
60	3.0

Construct a graph from these measurements. Use the graph to show that the resistance of the resistor is 50 Ω.

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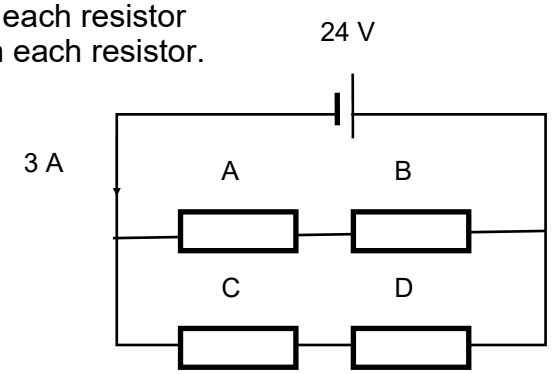
Homework 5 (Continued)

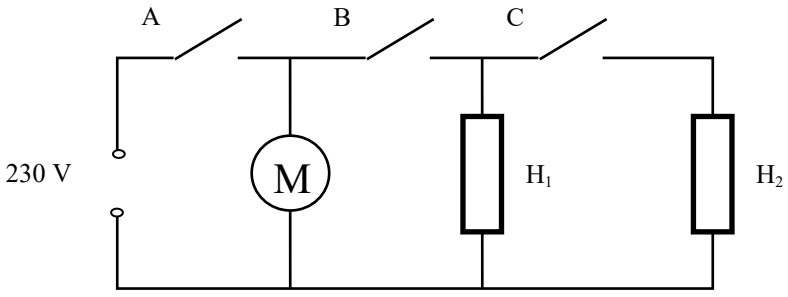
4. In the following circuit all the resistors are identical. Find:
   (a) the voltage across each resistor
   (b) the current through each resistor.



5. A lamp of resistance 5.0 Ω is connected in series to a 10 V supply . Calculate the current flowing through the lamp.

6. A vacuum cleaner connected to the mains draws a current of 3·1 A. What is the resistance of this appliance?

7. A hairdryer contains a motor and heating elements (resistors). The hairdryer shown below has three heat settings- cold, warm and hot. The circuit diagram shows how these settings are achieved using switches A, B and C.

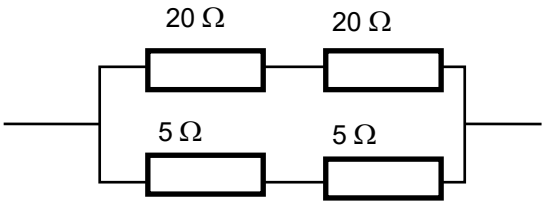


The motor draws a current of 3 A from the mains and the heating elements draw a current of 2 A each from the mains.

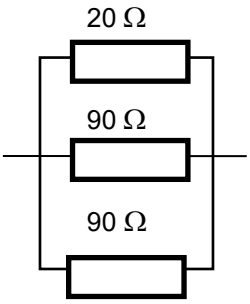
(*a*) Which switches must be closed to make the hairdryer blow warm air?
(*b*) What current is drawn from the mains when the hairdryer blows warm air?
(*c*) Which switches must be closed to make the hairdryer blow hot air?
(*d*) What current is drawn from the mains when the hairdryer blows hot air?
(*e*) What is the minimum current drawn from the mains when the hairdryer is on?
(*f*) What is the voltage across the motor?

Homework 6

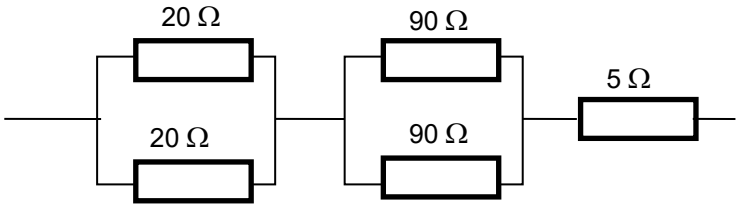
1 Daral has a selection of resistors and has to combine them in some way to obtain a total resistance of 60 Ω.
He has two 5 Ω, two 20 Ω and two 90 Ω resistors.
He sets up three different networks as shown below. Which one is correct?



Network 1



Network 2



Network 3

2. a) What will be the resistance of ten 20 Ω resistors when they are connected in series?
b) What will be the resistance of ten 20 Ω resistors when they are connected in parallel?

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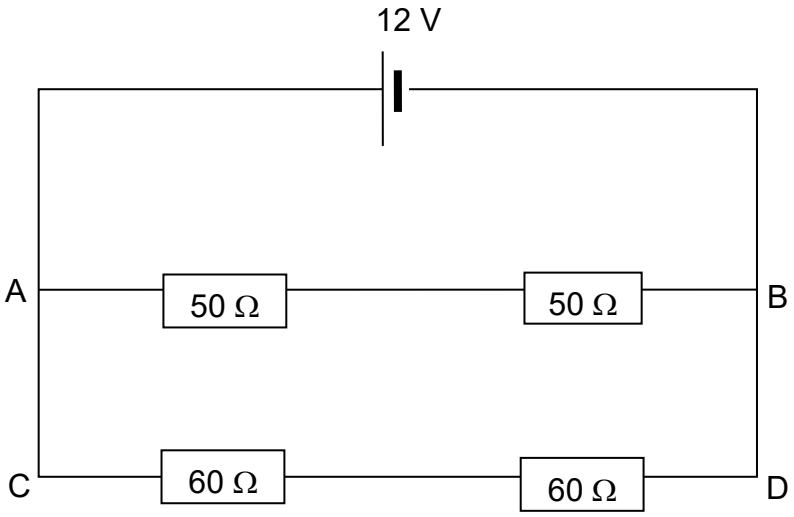
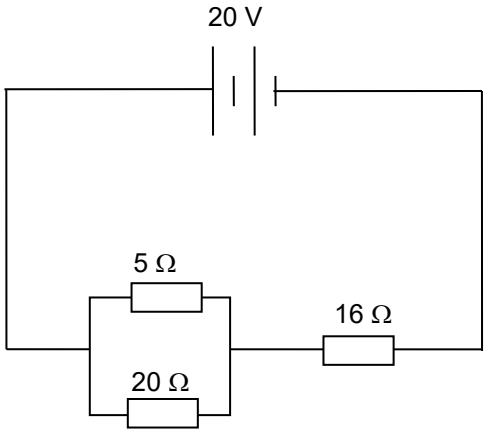
Homework 6 (Continued)

3. Look at the electrical circuit below:



a) What kind of circuit is this?
b) (i) Calculate the resistance across AB.
(ii) Calculate the resistance across CD.
(iii) Calculate the total resistance in the circuit.

4. A 20 V battery is connected across a circuit containing three resistors, as shown below.



a) Show that the total resistance of the circuit is 20 Ω.
b) The potential difference across the 16 Ω resistor is 16 V. What is the potential difference across the 20 Ω resistor?
c) Calculate the current flowing through the 20 Ω resistor.
d) What is the current flowing through the 5 Ω resistor?

Homework 7

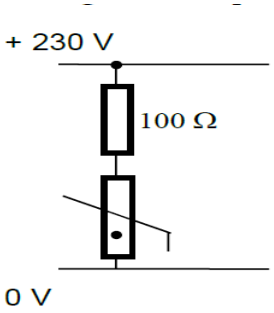
1. (a) Draw the circuit symbols for an NPN and MOSFET transistor.
   (b) Give one use for a transistor in an electronic circuit.

Use the following data to answer questions 2-4.

Thermistor

temperature (°C)	*resistance (Ω)*
10	4 000
40	1 980
100	200

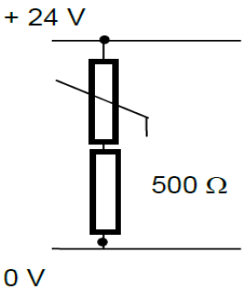
2. The following circuit is part of the input to an electronic frost alarm.



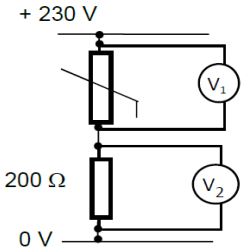
Calculate the potential difference across the thermistor when it is:
   (a) 10°C
   (b) 40°C.

3. Calculate the potential difference across the **resistor** in the following circuit when the temperature is:

   (a) 100°C
   (b) 40°C.



4. Determine the temperature at which the following voltmeters will show identical readings.



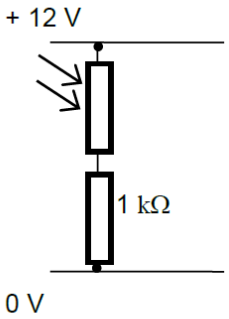
Use the following data to answer questions 7&8

Homework 7 (Continued)

Use the following LDR data to answer questions 5&6.

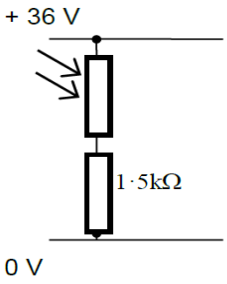
light condition	*resistance (Ω)*
dark	10 000
light	2 500
bright	20

5. The following circuit is part of a light meter for a camera.

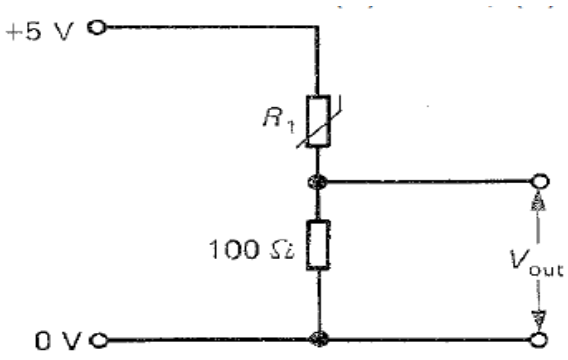


Find the potential difference across the LDR when it is:
(a) dark
(b) light.

6. An engineer designs part of an electronic system to trigger an alarm when it gets too bright.
Determine the 'trigger voltage' across the resistor in the following system when the light level becomes 'bright'.

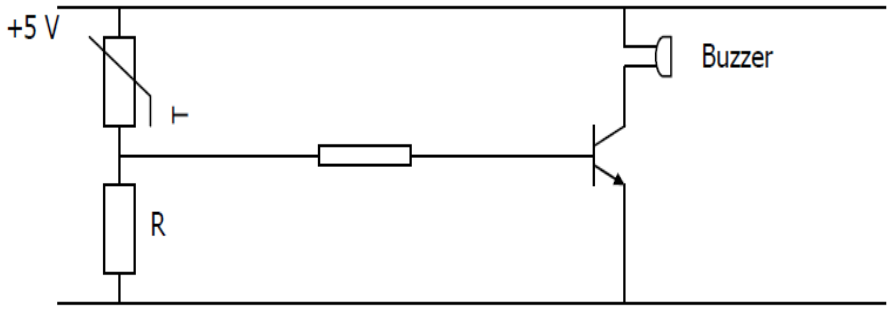


7. If the thermistor in the diagram below has a resistance of R1 of 400Ω at 20°C and 100Ω at 70°C, calculate V_{out} at:
(a) 20°C
(b) 70°C.



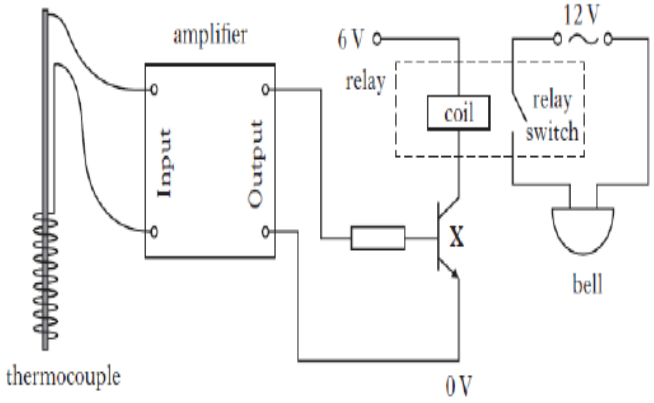
Homework 7 (Continued)

8. The circuit shown below is used as an alarm.



(a) The thermistor is positioned in a car engine. At normal engine temperatures, the transistor is OFF. What will happen if the engine overheats?
(b) Explain how the circuit works.

9. A student designs a circuit to act as a high temperature warning device. Explain how the circuit operates to sound the bell when the temperature of the thermocouple reaches a certain value.



Homework 8

1. Andrew purchases a lamp for his father's car. The lamp has "6 W, 12 V" marked on it. What current flows through it when it is working normally?

2. A 1 200 W hairdryer is switched on for 20 minutes. How much electrical energy does it use?

3. For how many minutes must a 600 W shaver be switched on in order to use 540 000 J of electrical energy?

4. An electric fire uses 5·22 MJ of electrical energy in half an hour. Calculate the power rating of the fire.

5. How long will it take a 1·4 kW paint stripper to use 1·68 MJ of electrical energy?

6. A microwave oven is on for 20 minutes each day. If it uses 7·98 MJ of electrical energy in one week, what is its power rating?

7. An electric locomotive on the East Coast line gets its electricity from the overhead cables which supply 25 kV a.c. The locomotive has a top speed of 140 mph and it operates at 4·7 MW. Calculate the current flowing to the locomotive.

8. A helium - neon laser emits red light and has many uses in medicine. The laser uses the 230 V mains supply and has a power rating of 5 mW. What current flows in the laser?

9. The current flowing in an electric keyboard is measured as 800 mA. What voltage is required to operate the keyboard if it has a power rating of 7·2 W?

10. Explain how power is lost as electricity travels along transmission lines.

Homework 9

1. It takes 8360J of heat energy to raise the temperature of 2 kg of water by 1ºC. How much heat energy will be required to raise the temperature of:
   (a) 4 kg of water by 1ºC
   (b) 4 kg of water by 5ºC
   (c) 8 kg of the water by 10ºC?

2. Calculate the amount of heat energy required to raise the temperature of
   (a) 0.5 kg of water from 18ºC to 58ºC? (The specific heat capacity of water is 4180 J/kg ºC).
   (b) a 0.85 kg steel baking tray from 18ºC to 198ºC (The specific heat capacity of steel is 500 J/kg ºC).

3. A well-insulated kettle contains 1.2 kg of water at a temperature of 20ºC. The kettle is switched on. After 180 s the water reaches a temperature of 100ºC. (The specific heat capacity of water is 4180 J/kg ºC).
   (a) How much energy is absorbed by the water in 180 s?
   (b) Calculate the power rating of the kettle.

4. A heater operating from a 12 V supply draws a current of 4 A. The heater is used to heat a 1 kg copper block. The heater is switched on for 5 minutes (The specific heat capacity of copper is 386 J/kg ºC).
   (a) How much heat energy was produced by the heater in 5 minutes?
   (b) Calculate the maximum possible rise in the temperature of the copper block.
   (c) Explain why the rise in temperature of the copper block will be less than the answer to (b).

5. How much energy is required to change 0.8 kg of ice at 0ºC into water at 0ºC? (The specific latent heat of fusion of ice is 3.34×10^5 J/kg).

6. How much energy is required to change 0.2 kg of steam at 100ºC into water at 100ºC? (The specific latent heat of vaporisation of steam is 2.26×10^6 J/kg).

7. A 2000 W heater is used to bring 1.5 kg of water to its boiling point. Calculate the mass of water boiled off if the heater is left on for a further 80 s (The specific latent heat of vaporization of water is 2.26×10^6 J/kg).

8. Explain why a bag with a mixture of ice and water is better at keeping things cool, compared to a bag of pure water at 0ºC.

9. Describe how to carry out an experiment to show what happens to temperature when something is freezing.

Homework 10

1. Convert the following celsius temperatures to kelvin.
   a) -273 °C b) -150 °C c) 0 °C

2. 0.01 m^3 of water is heated until it all changes to steam. What will be the approximate volume of the steam?

3. Explain why the use of large tyres helps to prevent a tractor from sinking into soft ground.

4. A box weighs 120 N and has a base area of 2 m^2. What pressure does it exert on the ground?

5. A rectangular steel block of mass 2kg measures 10 cm × 8 cm × 6 cm. What is the greatest and the least pressure which it can exert on a surface?

6. Explain the pressure-volume law qualitatively in terms of the kinetic model.

7. Describe an experiment to find the relationship between the pressure and volume of a fixed mass of gas at constant temperature. Your description should include:
   (a) a diagram of the apparatus used
   (b) a note of the results taken
   (c) an appropriate method to find the relationship using the results.

9. Air is trapped in a glass capillary tube by a bead of mercury. The volume of air is found to be 0.10 cm^3 at a temperature of 27 °C. Calculate the volume of air at a temperature of 87 °C.

10. The volume of a fixed mass of gas at constant temperature is found to be 50 cm^3. The pressure remains constant and the temperature doubles from 20 °C to 40 °C. Explain why the new volume of gas is not 100 cm^3.

11. 100 cm^3 of air is contained in a syringe at atmospheric pressure (10^5 Pa). If the volume is reduced to a) 50 cm^3 or b) 20 cm^3 without a change in temperature, what will be the new pressures ?

12. If the piston in a cylinder containing 300 cm^3 of gas at a pressure of 10^5 Pa is moved outwards so that the pressure of the gas falls to 8×10^4 Pa, find the new volume of the gas.

13. A weather balloon contains 80 m^3 of helium at normal atmospheric pressure of 10^5 Pa. What will be the volume of the balloon at an altitude where air pressure is 8×10^4 Pa?

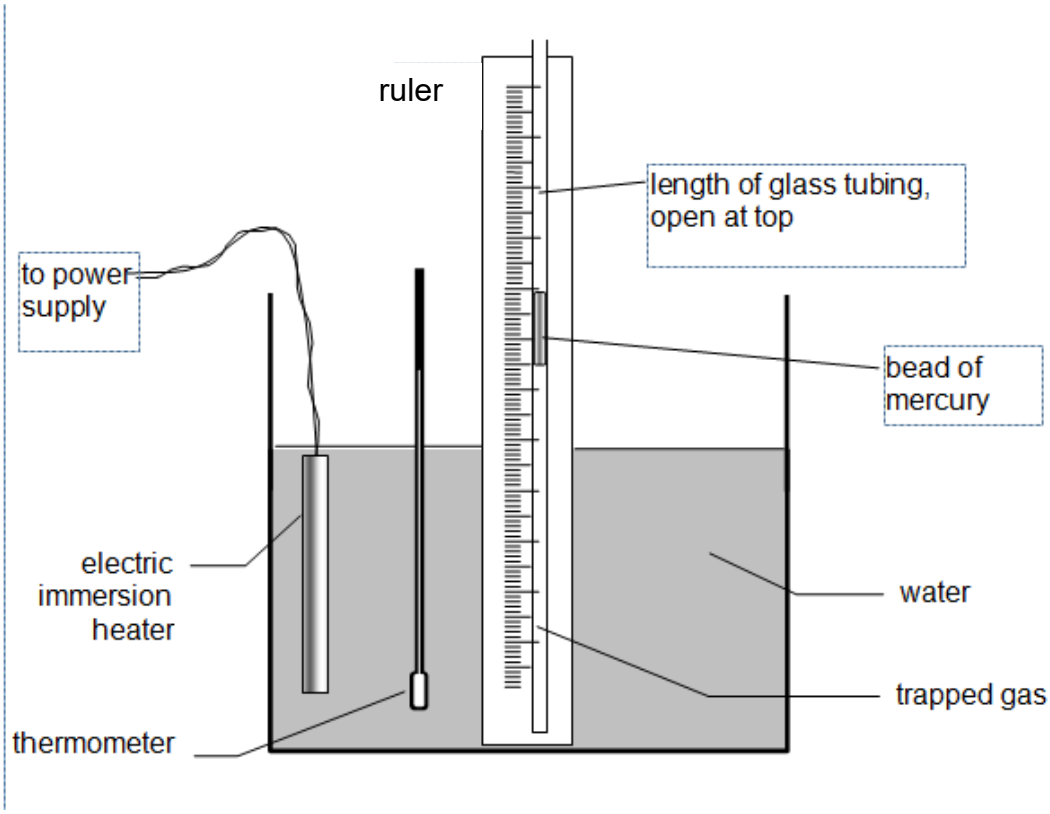
Homework 10 continued

14. An experiment is carried out to investigate the relationship between the volume and temperature of a gas, the apparatus is shown below. A column of gas is trapped by a bead of mercury and this is placed in a water bath. As the temperature of the surrounding water increases the water temperature is taken and the length of the trapped gas is recorded. The length of this trapped gas is proportional to its volume.

The results obtained from the experiment are given in the table below.

Length of tube/cm	21·5	22·9	24·4	25·9	27·3
Temperature of water in Kelvin	293	313	333	353	373

(*a*) Use all the data given above to show the relationship between the volume and temperature of the gas.
(*b*) Suggest one improvement that could be made to the apparatus which would improve the accuracy of the results obtained.



Homework 11

1. A cylinder of oxygen at 27 °C has a pressure of 3×10^6 Pa. What will be the new pressure if the gas is cooled to 0 °C?

2. An electric light bulb is designed so that the pressure of the inert gas inside it is 100 kPa (normal air pressure) when the temperature of the bulb is 350 °C. At what pressure must the bulb be filled if this is done at 15 °C ?

3. The pressure in a car tyre is 2.5×10^5 Pa at 27 °C. After a long journey the pressure has risen to 3.0×10^5 Pa. Assuming the volume has not changed, what is the new temperature of the tyre?

4. A compressed air tank which at room temperature of 27 °C normally contains air at 4 atmospheres, is fitted with a safety valve which operates at 10 atmospheres. During a fire the safety valve was released. Estimate the average temperature of the air in the tank when this happened.

5. Describe an experiment to find the relationship between the pressure and temperature of a fixed mass of gas at constant volume. Your answer should include:
   (a) a labelled diagram of the apparatus
   (b) a description of how you would use the apparatus
   (c) the measurements you would take.

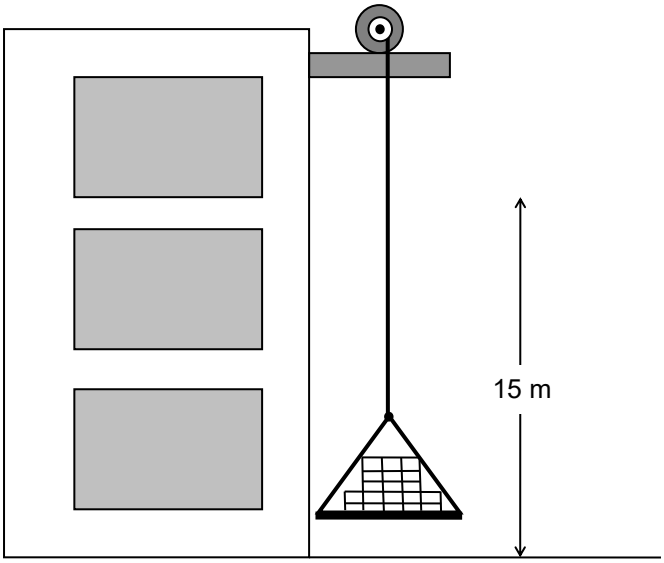
6. A sealed syringe contains 100 cm^3 of air at atmospheric pressure 10^5 Pa and a temperature of 27 °C. When the piston is depressed the volume of air is reduced to 20 cm^3 and this produces a temperature rise of 4 °C. Calculate the new pressure of the gas.

7. Calculate the effect the following changes have on the pressure of a fixed mass of gas.
   (a) Its temperature (in K) doubles and volume halves.
   (b) Its temperature (in K) halves and volume halves.
   (c) Its temperature (in K) trebles and volume quarters.

8. Explain qualitatively in terms of the kinetic model the laws for:
   (a) Pressure-temperature
   (b) Volume-temperature

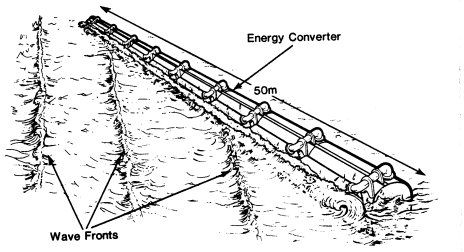
Homework 12 : Topic Revision

1. Builders have a portable electric hoist. It is being used to raise a platform and load of bricks with total mass of 50 kg 15 m up the side of a building.



(a) Calculate the gravitational potential energy gained by the platform and brick.
(b) The hoist exerts a constant force of 600N. Calculate the work done to raise the load.
(c) Explain why the answers to parts (a) and (b) are different.

2. Energy converters can be used to obtain energy from waves. The power levels available are, on average, 50 kW for every metre of wavefront.
(a) How much power is available if an energy converter covers 50 m of wavefront?
(b) Only 25% of this power is available as electricity. How much electrical power can be produced by this energy converter?
(c) What length of wavefront would be required to provide a small town with 10 MW of power.



3. Cling film is used to keep to keep food fresh. Cling film becomes sticky because of electrostatic charges.
a) Describe how a piece of cling film becomes charged.
b) Explain why cling film will stick to a plastic bowl for a long time but loses its sticking power quickly when placed on a metal bowl.

Continued on following page...

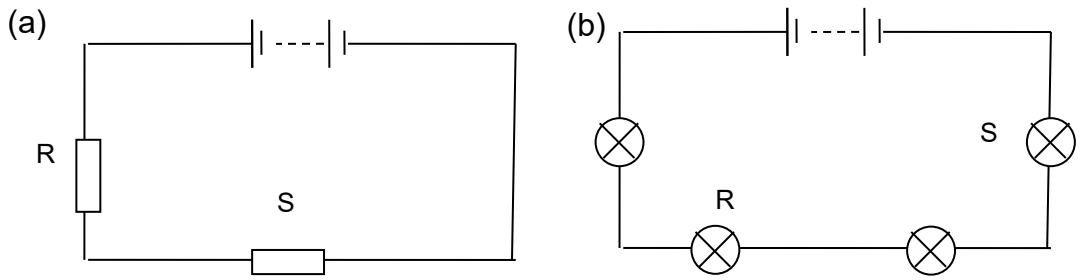
Homework 12 continued

4. When a kettle is switched on, there is a current of 10 A in the element. The kettle is switched on for 2 minutes. How much charge flows through the heating element in this time?

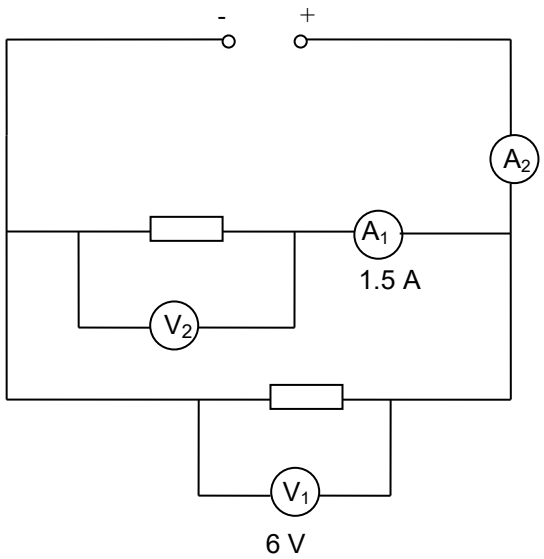
5. An electronic game works from a 9 V supply. What does a supply voltage of 9 V mean?

6. Draw the circuit symbol for:
(a) a battery, (b) a lamp, (c) a variable resistor, (d) a fuse.

7. Redraw each of the diagrams shown below to show how both a voltmeter is connected to measure the voltage across component R and an ammeter is connected to measure the current trough component S.



8. The circuit below has been set up with two identical resistors, what are the readings on:
(a) ammeters A_1 & A_2
(b) voltmeters V_1 & V_2



Homework 12 continued

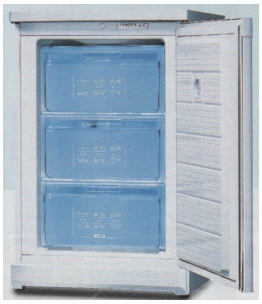
9. An electrical toaster is connected to the 230 V mains supply and switched on. A current of 4.5 A passes through the toaster element. Calculate the resistance of the elements.

10. Three resistors of value 47 Ω, 100 Ω, and 150 Ω are connected in series. Find the total resistance of these three resistors.

11. Three resistors of value 20 Ω, 20 Ω, and 10 Ω are connected in parallel. Find the total resistance of these three resistors.

12. An electric fire has three heating elements which can be switched on and off independently. Each element has a power of 1·3 kW and is controlled by a switch on the side of the fire.
    (a) Calculate the current drawn from the socket when one heating element is switched on.
    (b) What is the maximum current that the fire could draw?

13. Jenny carefully places four water-filled ice cube trays in an upright freezer. The total mass of the water in the trays is 0.80 kg and the temperature of the water is 15°C.
    (a) Show that to cool to freezing and turn to ice, the water must lose 320 kJ of heat energy.
    (b) The freezer pump removes heat from the cabinet at the rate of 200 J/s.
        (i) Assuming that heat is removed at this rate from the water, how long will it take to freeze the water from 15°C?
        (ii) Explain why the actual time to freeze the water will be longer than the time calculated in (b) (ii).



14. Convert the following kelvin temperatures to celsius.
    a) 10 Kb) 23 K c) 100 K

15. The cork in a pop-gun is fired when the pressure reaches 3 atmospheres. If the plunger is 60 cm from the cork when the air in the barrel is at atmospheric pressure, how far will the plunger have to move before the cork pops out?

16. Calculate the effect the following changes have on the volume of a fixed mass of gas.
    (a) Its temperature (in K) doubles and pressure halves.
    (b) Its temperature (in K) halves and pressure halves.
    (c) Its temperature (in K) trebles and pressure quarters.