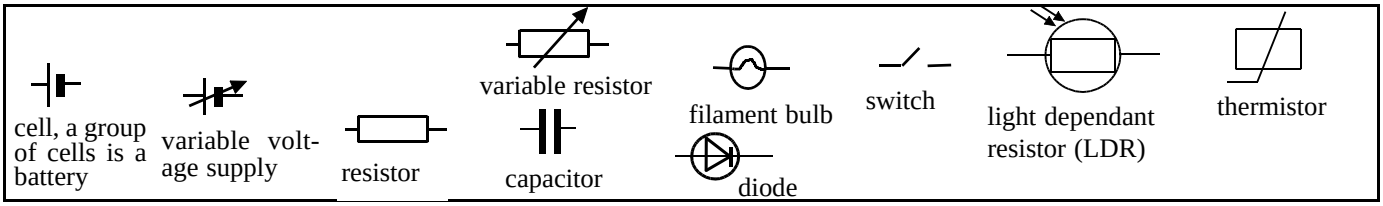
P6 ELECTRICITY FOR GADGETS

written by MJ Bradley



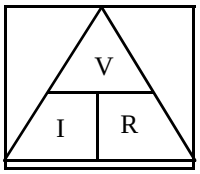
Current Electric current is the drift of charge through a conductor. In metals the charge is made of free electrons and it is negative. In liquids charge is made of positive or negative ions

quantity	symbol	unit	symbol
current	I	amp	A
voltage (pd)	V	volt	V
resistance	R	ohm	

Resistance.

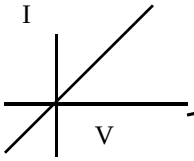
Nearly everything resists the flow of electric current. Good electric conductors have low resistance and current can be high. Insulators have a high resistance and current through them is low.

resistance = voltage / current $R = V/I$

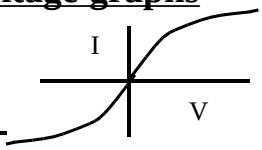


Example (1) What is current through a 2Ω resistor if the pd is 6V?
answer: I = V/R = 6/2 = 3A

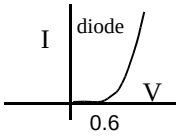
Current-Voltage graphs



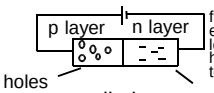
Ohmic resistor
Current is proportional to voltage and resistance (R=V/I) is constant



Filament bulb
As the filament gets hotter its resistance increases and current is no longer proportional to voltage

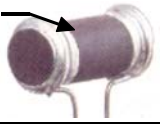


The diode has very large resistance for negative voltages. At +0.6V resistance drops dramatically. Diodes permit current in one direction only



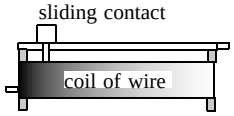
Thermistor and Light dependant Resistor(LDR)

A thermistor's resistance drops with increasing temperature

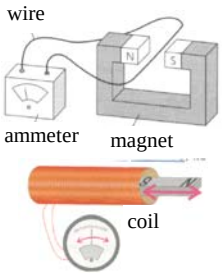


The resistance of an LDR drops with increased light

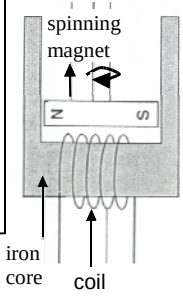
Variable Resistors: These work by a sliding contact moving along a resistance wire. The longer the wire the greater the resistance



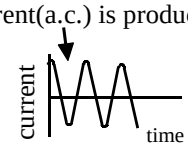
Generating Electricity If a wire is moved through a magnetic field current is produced. The same effect can be achieved by using a coil of wire and moving the magnet in and out of the coil. The current is increased by moving the magnet faster, a stronger magnet, or more turns of wire in the coil. If the magnet is reversed the current direction reverses



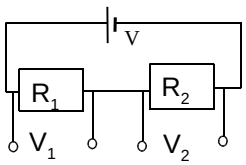
A.C. generator



In this generator the magnet spins and because the field direction constantly reverses so does the current direction. Alternating current(a.c.) is produced



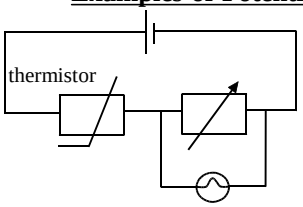
Potential Divider (sharing voltage)



In a series circuit voltage is shared across the resistors. The amount of the share is calculated by theses equations. A potential divider can control voltage in a circuit

$V_1 = \frac{VR_1}{(R_1+R_2)}$ $V_2 = \frac{VR_2}{(R_1+R_2)}$

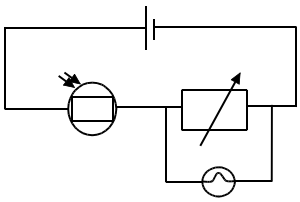
Examples of Potential Divider Circuits



As the temperature increases the thermistor resistance drops and so does its share of the voltage. There is more voltage across the resistor and the bulb gets brighter

What would be the effect of increasing the resistance? answer: The bulb will switch on at a lower temperature.

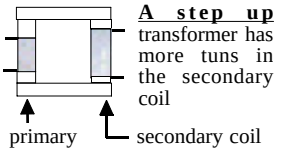
In this circuit as it gets brighter the resistance of the LDR decreases, its share of the voltage decreases. There is now more voltage across the variable resistor and the bulb turns on



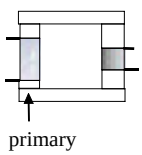
What would be the effect of increasing the resistance? ans: It would not need to get as bright before the bulb lights

Transformers are used to step up the voltage at power stations and to step down voltage near our homes in a sub-station. Transformers only work with **A.C.**

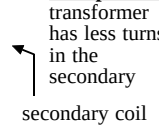
How do they work? The alternating current delivered to the primary produces an alternating magnetic field which cuts across the secondary coil and a voltage is produced. Direct current (d.c) would not work because the current is steady and the magnetic field stationary.



A step up transformer has more tuns in the secondary coil



A step down transformer has less turns in the secondary



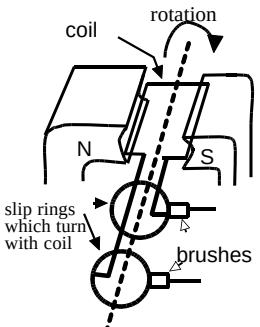
The output voltage is related to the ratio of the number of turns in the primary and secondary coils

$\frac{\text{secondary voltage}}{\text{primary voltage}} = \frac{\text{Nº of turns in secondary}}{\text{Nº of turns in primary}}$ $\frac{V_s}{V_p} = \frac{N_s}{N_p}$

Example What is the secondary voltage from a transformer if the input voltage is 10V, there are 100 turns in the primary and 1000 turns in the secondary?
answer $V_s = \frac{N_s}{N_p} \times V_p = \frac{1000}{100} \times 10 = 100V$
This is a step up transformer

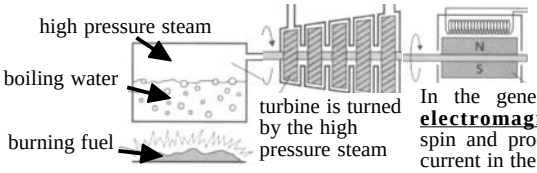
Transformer Efficiency If energy losses are ignored power to primary = power output from secondary
$I_pV_p = I_sV_s$ so $V_s = \frac{I_pV_p}{I_s}$

Transporting Electricity: Energy loss is proportional to the square of the current flowing. if V_s is made very high I_s is small and so energy loss is reduced



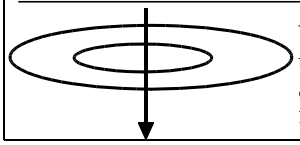
In this A.C. generator a coil rotates in a magnetic field. The coil it attached to slip rings which rub against contacts (brushes). The coil has to be made to rotate

Generating Electricity at a Power Station



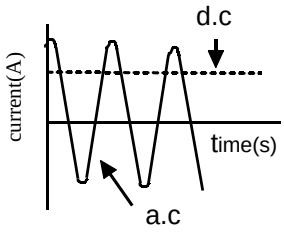
In the generator **electromagnets** spin and produce current in the coil

Electric Current and Magnetism



When current flows through a conductor a **circular** magnetic field is produced

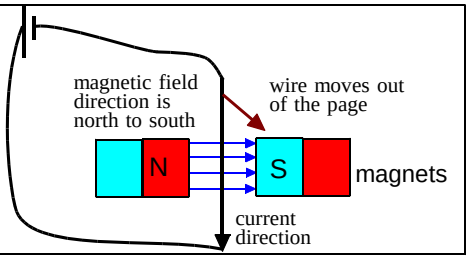
Alternating Current and Direct Current



Alternating Current constantly reverses direction House electrical sockets deliver A.C. Direct current flows in one direction only and is the sort of current obtained from batteries

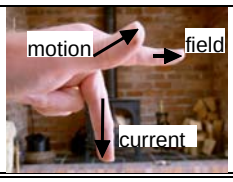
The Motor Effect

If current passes through a wire the magnetic field that is produced around it can interact with the permanent magnetic field from a magnet and the wire experiences a force. If the current is reversed so is the force. Alternating current would make the wire move forwards and backwards

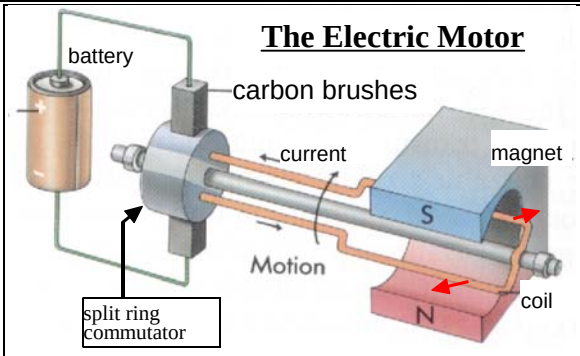


Flemmings Left Hand Rule

Place your thumb and first two fingers at **right angles.** Place your first finger in the direction of the field and your second finger in the direction of the current. Your thumb gives you the direction of movement



The Electric Motor



Current from the battery enters the coil via a carbon brush and the split ring commutator. The sides of the coil experience force in opposite directions because the current is flowing in opposite directions and the coil spins on its axis. Use the left hand rule to check this out for yourself

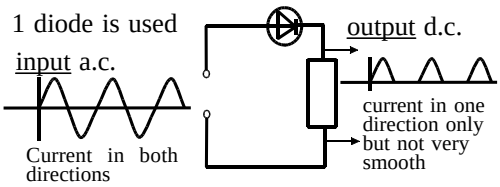
Converting a.c to d.c

Devices that work off batteries like your mobile phone use d.c. To charge a mobiles' battery mains a.c needs to be **rectified** (changed) to d.c

Diodes:These allow current to flow in one direction only - great for converting a.c. to d.c.

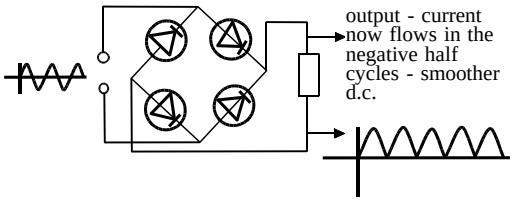
Half wave rectification

1 diode is used

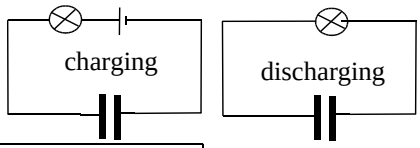


Full wave rectification

4 diodes are used in a 'bridge' circuit

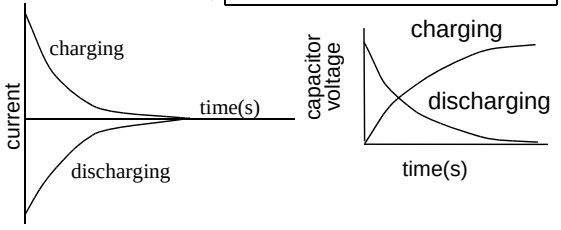


Capacitors: These store charge. When they discharge current flows

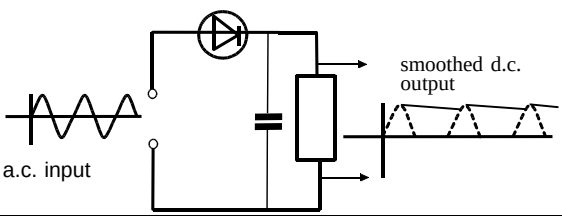


When charging the current quickly drops. At full charge the current is zero and the voltage is maximum

With the voltage supply removed the capacitor discharges and current flows in the opposite direction. The current and the capacitor voltage quickly reduces to zero



Smoothing d.c. in rectifier circuits



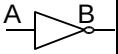
When the voltage is positive the current can flow and the capacitor also charges. When the voltage is negative no current can flow back through the diode. Instead the capacitor discharges through the resistor helping to maintain the current

Electronic Circuits

inputs → processing (logic gates) → outputs

In electronics the 'on' state is represented as logic 1

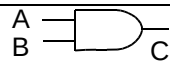
NOT gate



The not gate reverses logic

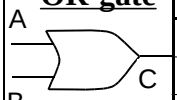
input A	output B
1	0
0	1

AND gate



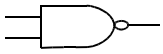
input A	input B	output C
1	0	0
0	1	0
0	0	0
1	1	1

OR gate



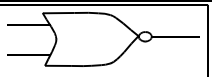
input A	input B	output C
1	0	1
0	1	1
0	0	0
1	1	1

NAND gate



This is an AND gate followed by a NOT

NOR gate

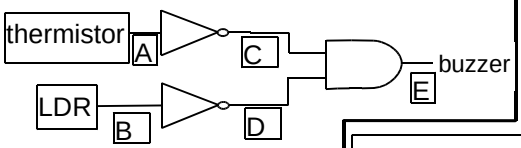


This is an OR gate followed by a NOT

input/output	logic 1	logic 0
switch	on	off
thermistor	hot	cold
LDR	bright	dark
bulb	on	off
buzzer	on	off

Circuit Problem Example:

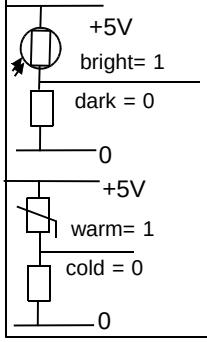
A gardener wants a buzzer to sound if it is night time and it is freezing outside



Truth table

input A	input B	C	D	output E
1	0	0	1	0
0	1	1	0	0
1	1	0	0	0
0	0	1	1	1

Potential Dividers and Logic



As it gets brighter the LDR resistance gets less and the voltage across the resistor increases to a level that represents logic 1

As it gets warmer the LDR resistance gets less and the voltage across the resistor increases to a level that represents logic 1

What is a relay?This is a switch which uses a small current to switch on a bigger current in a separate circuit. This makes it safer to operate and saves the need for lots of thick wiring

REVISION EXERCISE UNIT P6

fold along dotted line

written by MJ Bradley

1) Draw the circuit symbol for (a) thermistor, (b) light dependant resistor,

2) Resistance = $\frac{?}{?}$ R = $\frac{?}{?}$

3) A resistor passes a current of 3A when the potential difference is 30V. What is the resistance? [4]

4) What current will flow through a 10W resistor when the voltage is 4V?

5) A diode permits current flow in _____ direction

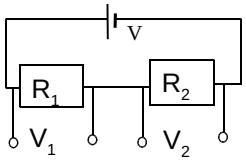
6) A thermistors resistance _____ as the temperature gets higher

7) The resistance of a LDR _____ as light levels increase

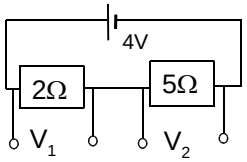
8) A potential divider splits _____

9) Use the correct symbols to write an equation for (a) V_1, (b) V_2

9c)What will happen to voltage V_2 if resistance R_1 is increased?



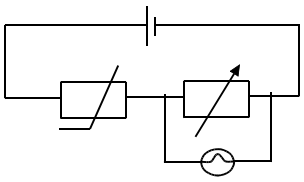
10) In this potential divider circuit what is (a) V_1, (b) V_2?



11) When it is hot the thermistor resistance is low, the voltage share across the thermistor gets _____ and across the variable resistor gets _____ and the bulb gets _____

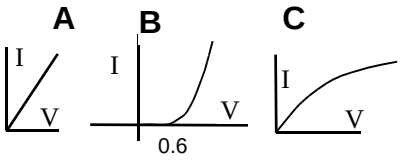
As it gets colder the thermistor resistance increases and the voltage across it _____. At the same time the share of the voltage across the variable resistor gets _____ and the bulb goes _____

If resistance from the variable resistor is increased the bulb will light at a _____temperature



12) Match the current voltage graph to the correct circuit component

filament bulb, diode, ohmic resistor

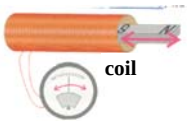


13) For negative voltages a diodes resistance is very _____

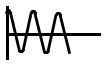
14) For an ohmic resistor current is _____ to voltage (at steady temperature)

15) Why is current not proportional to voltage in a filament lamp?

16) To generate current the magnet must be _____. The magnetic _____ around the magnet cuts across the coils and current is produced. The current can be increased by moving the magnet _____ or by having a _____ magnet or by having _____ turns in the coil. The current direction is reversed by .....

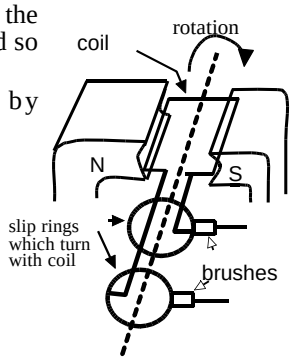


17) What type of current does this graph represent?



18) In this a.c. generator after half a turn the side of the coil which **was** moving up is **now** moving _____ and so the current direction is _____.

18b) The current could be increased by .....



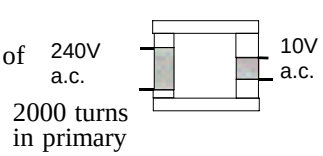
19) A step up transformer _____ voltage and has _____ turns in the _____ coil than in the primary coil

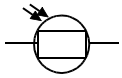
20) A step down transormer _____ voltage and has _____ turns in the secondary than in the primary coil

21) A transformer changes voltage in proportion to the change in the number of _____ in the primary and secondary

22) The transformer equation is?

23) What is the number of turns in the secondary coil of this transformer?



1a)  1b) 

2) resistance = $\frac{\text{voltage}}{\text{current}}$ $R = \frac{V}{I}$

3) R = V/I = 30/3 = 10Ω

4) I = V/R = 4/10 = 0.4 A

5) One

6) drops

7) drops

8) voltage

9a) $V_1 = \frac{VR_1}{(R_1+R_2)}$ 9b) $V_2 = \frac{VR_2}{(R_1+R_2)}$

9c) It will get less (look at the equation)

10a) $V_1 = \frac{4x2}{(2+5)} = \frac{8}{7} = 1.14V$

10b) $V_2 = \frac{4X5}{(5+2)} = \frac{20}{7} = 2.86V$

11) less, more, brighter

increases, less, dim

lower

12) **A** - ohmic resistor **B - diode**

C - filament bulb

13) High

14) proportional

15) resistance increases as it gets hotter

16) moving, field

faster, stronger, more

moving the magnet in the opposite direction

17) a.c.

18) up, reversed

18b) spinning the coil faster or stronger magnet or more turns in the coil

19) increases, more, secondary

20) reduces, less

21) turns

22) $\frac{V_s}{V_p} = \frac{N_s}{N_p}$

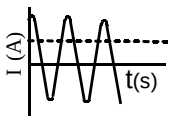
23) $N_s = \frac{N_p V_s}{V_p} = \frac{2000X10}{240} = 83$ turns

REVISION EXERCISE UNIT P6

fold along dotted line

written by MJ Bradley

24) Label the diagram with a.c. and d.c.



25) What type of current do transformers use?

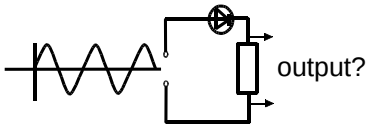
26) What is this circuit symbol?

27) In how many directions does a.c. flow?

28) In how many directions does d.c. flow?

29) Why is a diode useful for converting a.c. into d.c.?

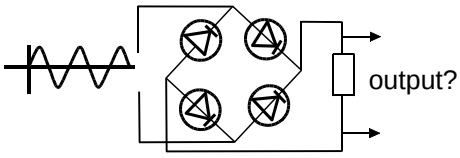
30) a.c. is supplied to this diode and resistor. Sketch the output current



30b) What type of rectifier circuit is this?

31) What type of a.c. to d.c. rectifier circuit uses 4 diodes?

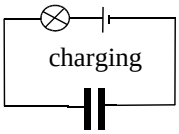
31b) Sketch the output from this circuit when it is supplied with a.c.

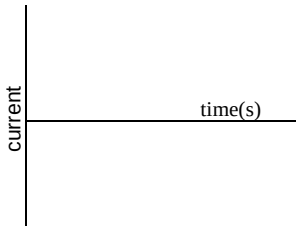


32) What does a capacitor store?

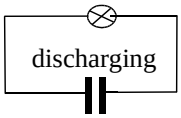
33) What flows when a capacitor discharges?

34) A capacitor can be charged using this circuit. Sketch how current changes with time when the battery connection is made

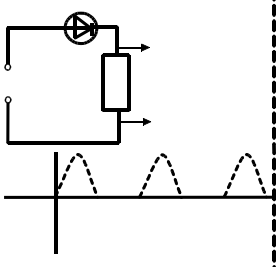




34b) On the same graph sketch how current from the capacitor changes when it is discharged



35) In an a.c.to d.c. rectifier circuit d.c. can be smoothed using a _____. When the voltage is negative the capacitor _____ maintaining the _____



36) Sketch how half wave rectified d.c. is smoothed when a capacitor is used

37) What type of field surrounds a wire carrying a current?

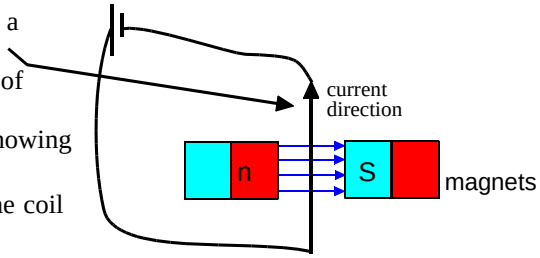
37b) What shape is this field?

38) Why does this wire move when a current flows?

39) What rule enables the direction of movement to be predicited?

40) Draw an arrow from the wire showing its direction of movement

41) In an electric motor How can the coil be made to spin faster?



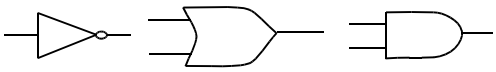
42) In electronic 'on' is logic ___ and 'off' logic __

43) A ____ gate reverses logic

44) Which gate has an output of logic 1 if both inputs are logic 1?

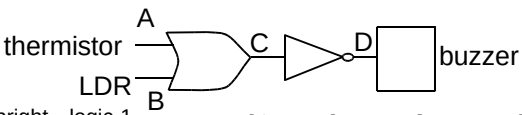
45) When does an OR gate give an output of logic 1?

46) Identify and label each logic gate



47)Complete the truth table for the circuit below

warm - logic 1
cold - logic 0



bright - logic 1
dark - logic 0

A	B	C	D
1	0		
1	0		
0	0		
1	1		

47b) In what conditions will the buzzer sound?

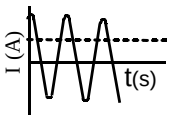
47c) What type of gate does this circuit represent?

48) What is a NAND gate?

49) A _____ _____ can be used to provide the logic 1 and 0 for logic gates.

50) What is the symbol for a NOR gate?

24)



25)a.c.

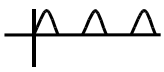
26) diode

27) two

28) one

29) It allows current to flow in one direction only

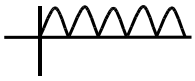
30)



30b) Half wave

31) full wave

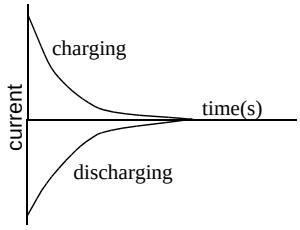
31b)



32) charge

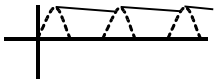
33) current

34+34b



35) capacitor, discharges, current

36



37) magnetic

37b) circular

38) magnetic field from wire interacts with field from magnets

39) Flemmings left had rule

40) arrow from wire **into** the page

41) more current, stronger magnets, more turns

42) 1, 0

43)NOT

44) AND

45) When either input is logic 1

46) NOT OR AND

47)

A	B	C	D
1	0	1	0
1	0	1	0
0	0	0	1
1	1	1	0

47b) cold and dark

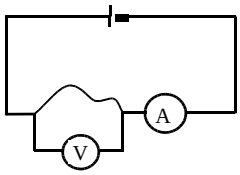
47c) NOR

48) AND gate followed by a NOT

49) potential divider

50)

UNIT P6 ASSESSMENT



NAME _____

1(a) Dave builds a circuit. He uses a piece of resistance wire. Look at the diagram.

(i) The current in the wire is 0.2 amps. The voltage across the wire is 12V. Calculate the **resistance** of the wire. _____

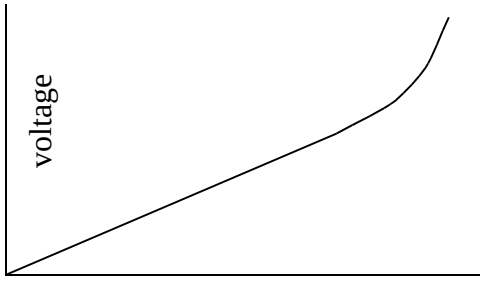
_____[2]

(ii) Dave leaves the circuit connected and takes some more readings. The wire gets hot. Look at the graph of his results. Describe and explain the shape of this graph. Use ideas about **resistance** in your answer.

_____

_____

_____[3]



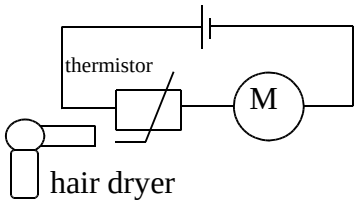
(b) Dave puts a motor and a **thermistor** in a circuit. Look at the diagram. Dave makes the thermistor **hotter** using the hair dryer.

(i) What happens to the **speed** of the motor? _____[1]

(ii) Explain your answer._____

_____

_____[1]

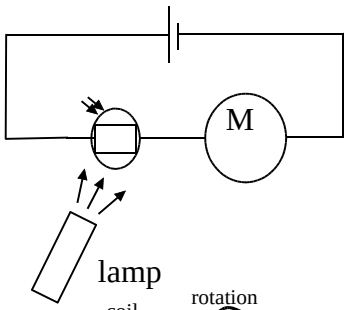


(c) Dave replaces the thermistor with a light dependent resistor (LDR) in his motor circuit. Look at the diagram. Dave switches on the lamp. More light hits the LDR.

(i) What happens to the **speed** of the motor? _____[1]

(ii) Explain your answer. _____

_____[1]



2 This question is about electric motors.

Look at the diagram of the simple DC electric motor. A current flows through the coils. The motor spins. Alex wants to make the coil spin **faster**. Explain how he can do this.

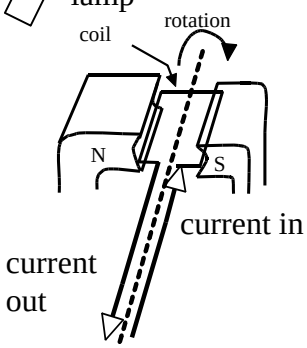
In your answer write about: **(i)current, (ii) coils, (iii) magnetism.**

_____

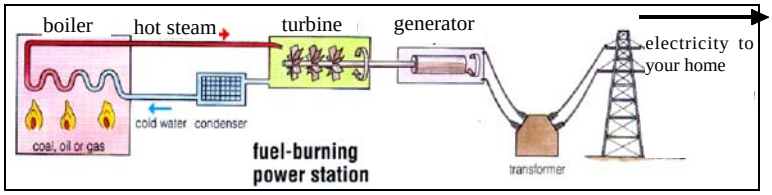
_____

_____

_____[3]

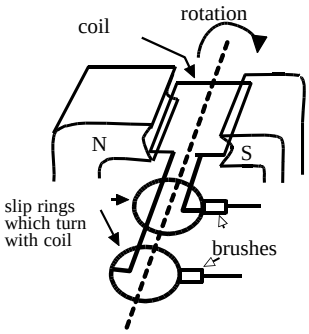


3 This question is about power generation and electrical transformers. The transformer increases the voltage from the power station to the transmission cables.



(a) There is a generator in the power station.

Look at the diagram of an AC generator. The coil spins and produces an output voltage.



Generator

(i) The coil spins **faster**. What happens to the **size** of the output voltage?

_____

What happens to the **frequency** of the output voltage?

_____[2]

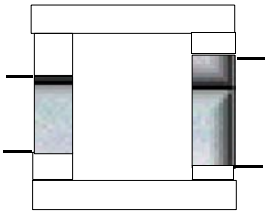
(ii) The coil is replaced. The new coil has **more** turns. What happens to the size of the **output** voltage? _____[1]

(b) Look at the diagram of the step-up transformer.

(i) The AC voltage produces a changing magnetic field in the primary coil. Explain how this produces an output voltage in the secondary coil. _____

_____

_____[2]



primary coil
20 000V input voltage
3 000 turns

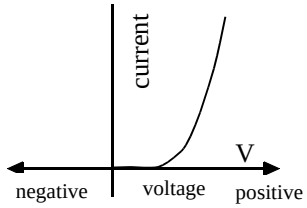
secondary coil
400 000V output voltage

(ii) The input voltage is 20 000V. The primary coil has 3 000 turns. The output voltage is 400 000V. Calculate the number of turns in the secondary coil.

_____

_____[2]

4 Alice measures the current and voltage for a diode. Look at the graph of her results.

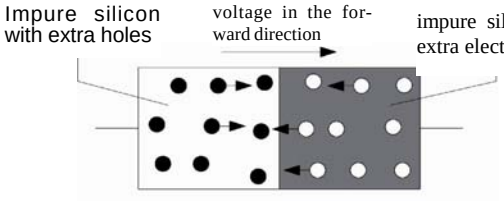


(a) Complete the following sentences about this diode. Choose your answers from

forwards high low negative positive reverse

When the voltage is positive the resistance is _____ in the _____ direction. When the voltage is _____ the resistance is _____ in the **reverse** direction. [2]

(b) The diode is made of silicon. Look at the diagram



(i) The voltage is in the **forward** direction.

Explain what happens to the holes and electrons in the diode.

_____

_____[2]

(ii) The voltage is changed to the **reverse** direction. Explain what happens to the holes and electrons in the diode.

_____

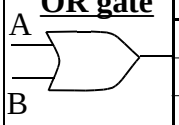
_____[2]

5) This question is about logic gates.

(a) Complete the outputs for the OR gate

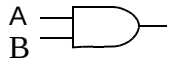
(b) Complete the outputs for the AND gate [2]

OR gate



input A	input B	output C
1	0	
0	1	
0	0	
1	1	

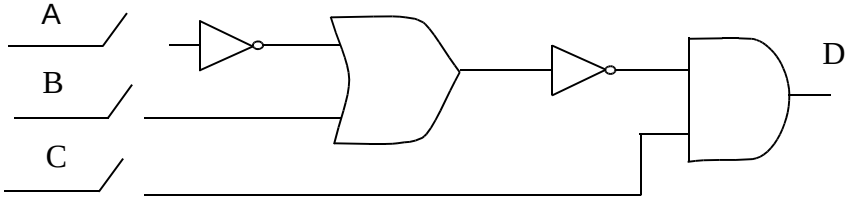
AND gate



input A	input B	output C
1	0	
0	1	
0	0	
1	1	

(c) Logic gates have to be connected to a **relay** before they control mains circuits. Explain **two** reasons why a relay is needed._____

_____[2]



(d) Logic gates can be made to control a combination lock. Look at the diagram. It shows the three inputs to the lock. The lock will only open when there is a **high** output at D. What combination of inputs will open the lock?

Complete the table. [1]

INPUT	on or off?
A	
B	off
C	