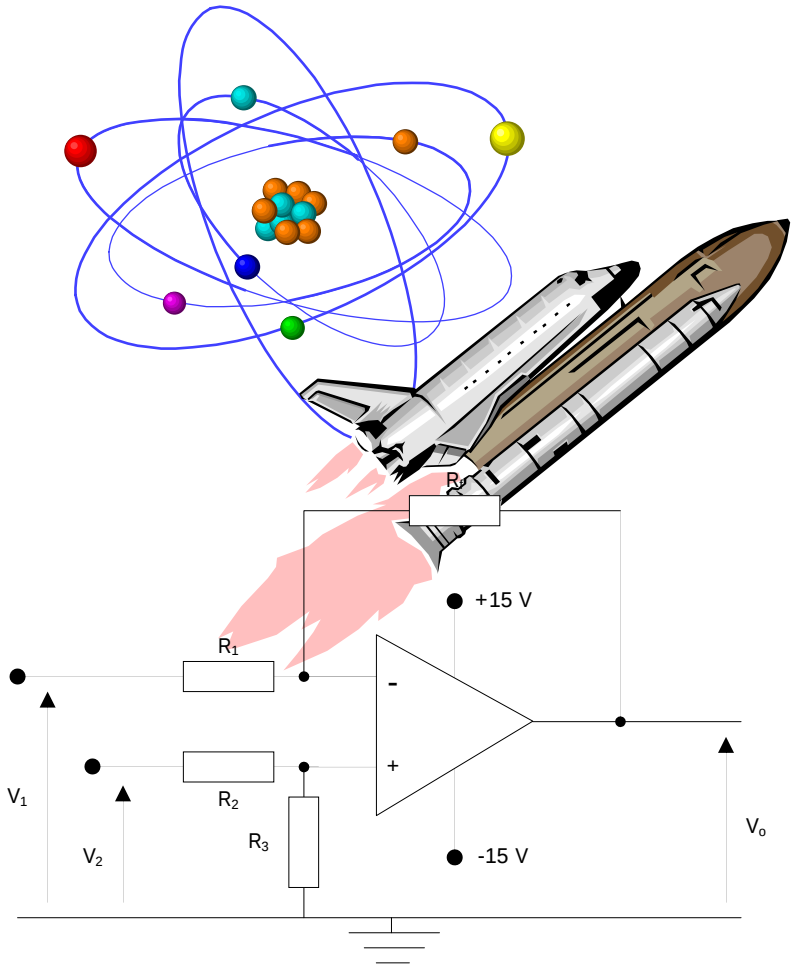
Higher Physics

Name:

Musselburgh Grammar

Physics Department

Unit Homework Package



- HOMEWORK TRACKING SHEET
- UNCERTAINTIES & SIGNIFICANT FIGURES - 2 HOMEWORK EXERCISES
- MECHANICS & PROPERTIES OF MATTER - 6 HOMEWORK EXERCISES
- ELECTRICITY & ELECTRONICS - 6 HOMEWORK EXERCISES
- RADIATION & MATTER - 6 HOMEWORK EXERCISES

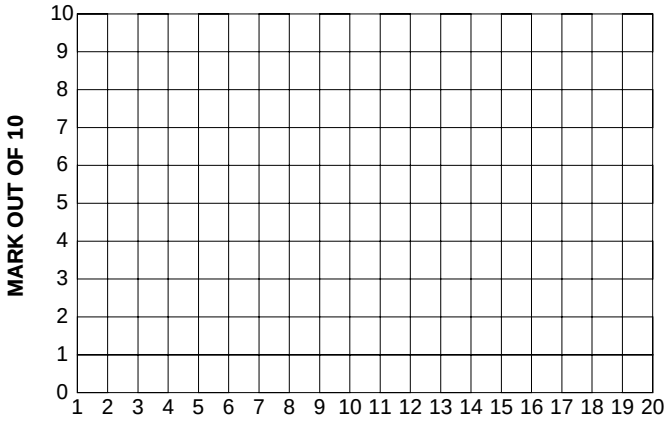
HOMEWORK TRACKING SHEET
Pupil Record

NAME: _____ **CLASS:** _____

TEACHER: _____ **YEAR:** _____

Keep a note of your Higher Physics formal homework exercises on this sheet. The Due Date should be filled in whenever you are told it, to ensure there are no misunderstandings about deadlines. Once the homework has been returned, fill in the mark in the appropriate column, and also on the chart below. Join the previous homework mark to the current one with a straight line. This chart will allow you to instantly spot where your weaknesses are when it comes to your revision for Unit Tests, the Prelim, and your final exam. Use the table at the bottom to keep your own note of what stage you are at with Unit Tests and Learning Outcome 3 experiments. Fill in your mark for the Unit Test (and resit, if you needed it), and put 'YES' in the 'ATTAINED' column if you reach the threshold of attainment. For the LO3 column, put 'YES' in the 'ATTAINED' column when you have passed the experimental report.

		HOMEWORK EXERCISES	DUE DATE	MARK	SIGNATURE
Other	1	SIGNIFICANT FIGS & SCIENTIFIC NOTATION			
	2	UNCERTAINTIES			
UNIT 1 MECHANICS & PROPERTIES OF MATTER	3	VECTORS			
	4	EQUATIONS OF MOTION			
	5	FORCES			
	6	MOMENTUM & IMPULSE			
	7	PRESSURE & DENSITY			
	8	GAS LAWS			
UNIT 2 ELECTRICITY & ELECTRONICS	9	ELECTRIC FIELDS			
	10	RESISTORS, EMF & INTERNAL RESISTANCE			
	11	WHEATSTONE BRIDGES			
	12	A.C. & CAPACITORS			
	13	CAPACITORS IN CIRCUITS			
	14	ANALOGUE ELECTRONICS			
UNIT 3 RADIATION & MATTER	15	WAVES			
	16	REFRACTION OF LIGHT			
	17	OPTOELECTRONICS			
	18	SEMICONDUCTORS			
	19	NUCLEAR REACTIONS			
	20	DOSIMETRY & SAFETY			



MECHANICS & PROPERTIES OF MATTER				ELECTRICITY & ELECTRONICS				RADIATION & MATTER				PRELIM EXAM	
LOs 1 & 2			LO3	LOs 1 & 2			LO3	LOs 1 & 2			LO3	MARK	
ASSESS.	RESIT	ATTAINED	ATTAINED	ASSESS.	RESIT	ATTAINED	ATTAINED	ASSESS.	RESIT	ATTAINED	ATTAINED	%AGE	
/30	/30			/30	/30			/30	/30			GRADE	

FORMAL HOMEWORK EXERCISE
Induction - Uncertainties & Significant Figures

Homework 1 - Significant Figures, Prefixes & Scientific Notation

1. In each of the following cases, the stated value has too many significant figures. The appropriate number of significant figures is stated in brackets after the quantity. Round each quantity to the correct number of significant figures.

   (a) 11.85467 V **(3 significant figures)**
   (b) 50.7835 Hz **(2 significant figures)**
   (c) 0.000000712 m **(3 significant figures)**
   (d) 2.998×10^{8} ms^{-1} **(2 significant figures)** (2)

2. Calculate the following quantities from the information given, and report your answer to an appropriate number of significant figures. Remember to give your answer in scientific notation!

   (a) Calculate the frequency of microwaves that have a wavelength of 3.1×10^{-2} m, and are travelling at 3.0×10^{8} ms^{-1}. (1½)

   (b) Calculate the energy used if a 1.2 kW kettle takes 2 minutes (1.2×10^{2} s) to boil. (1½)

3. Copy the table below, and fill in all the blanks. (2)

QUANTITY	VALUE	SCIENTIFIC NOTATION
Speed of light		3×10^{8} ms^{-1}
Charge on an electron	0.000 000 000 000 000 000 160 C	
Wavelength of red light		7×10^{-7} m
Voltage used in the Super Grid	250 000 V (to 3 sig figs)	

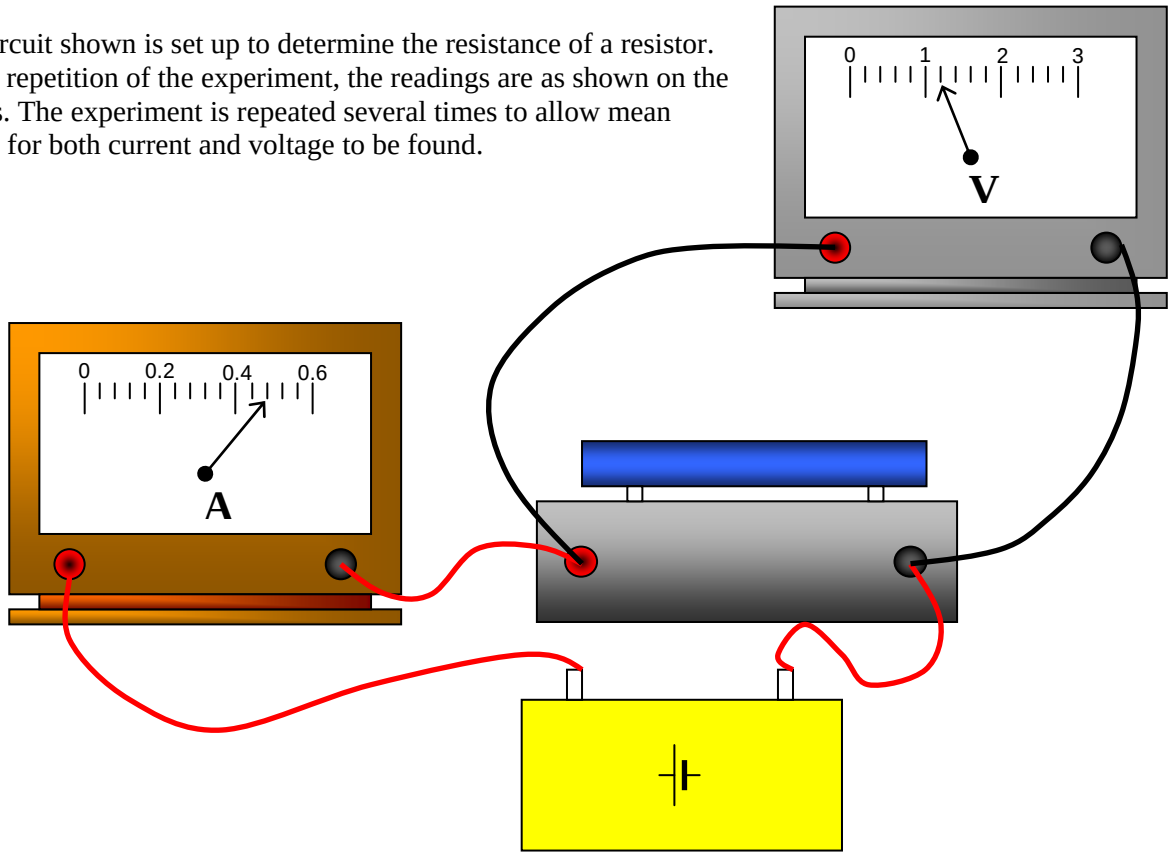
4. Re-write the following quantities using the most appropriate prefix. (3)

   (a) 0.000 006 m
   (b) 1 500 000 000 Hz
   (c) 3200 W
   (d) 0.008 g
   (e) 2.7×10^{6} J
   (f) 7.42×10^{-7} m

TOTAL 10 MARKS

Homework 2 - Uncertainties

1. The circuit shown is set up to determine the resistance of a resistor. In one repetition of the experiment, the readings are as shown on the meters. The experiment is repeated several times to allow mean values for both current and voltage to be found.



(a) Give the ammeter and voltmeter readings and state the scale reading uncertainty in each case. (2)

(b) Using Ohm's Law (**V = IR**), calculate a value for the resistor. Estimate the **absolute** uncertainty in the calculated value of the resistance and explain how you arrived at your estimate. (3)

(c) The experiment is repeated 5 times, and the values recorded for the current are as follows:

0.44 A; 0.43 A; 0.45 A; 0.42 A; 0.44 A

Calculate the mean current, and the random uncertainty in the mean. (3)

2. A current is measured with an analogue meter which has scale divisions of 0.1 A, and is found to be 5.4 A. The reading is double-checked with a digital meter, and again is found to be 5.4 A. Using which instrument gives the larger scale reading uncertainty? Explain your answer. (2)

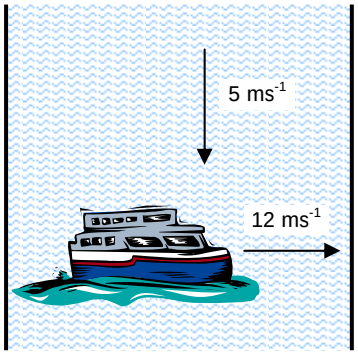
TOTAL 10 MARKS

Homework 3 - Vectors

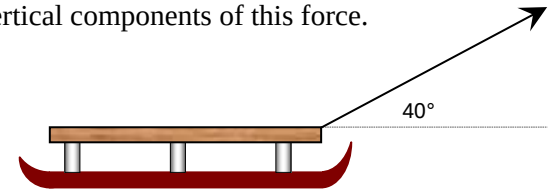
1. (a) Explain the difference between a vector and a scalar quantity. (1)

   (b) Give 2 examples each of a vector and a scalar quantity. (1)

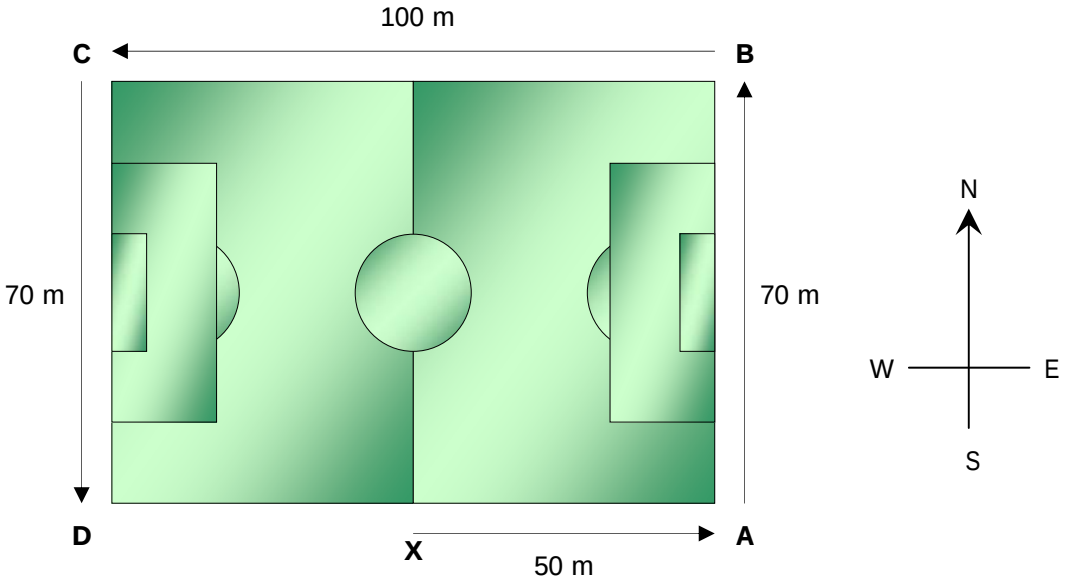
2. A ferry crosses a river that is flowing at 5 ms^{-1}. If the ferry is travelling at 12 ms^{-1}, calculate its resultant velocity. (2)



3. A boy using a force of 250 N pulls a sledge across the snow as shown in the diagram below. Calculate the horizontal and vertical components of this force. (2)



4. A footballer runs around a football pitch as part of his training. He starts at the halfway line (*point X*), and runs around the pitch to point *D* as shown. This run takes him 50 seconds.



   (a) Calculate the total distance travelled by the footballer. (1)

   (b) What is his final displacement at point *D*? (1)

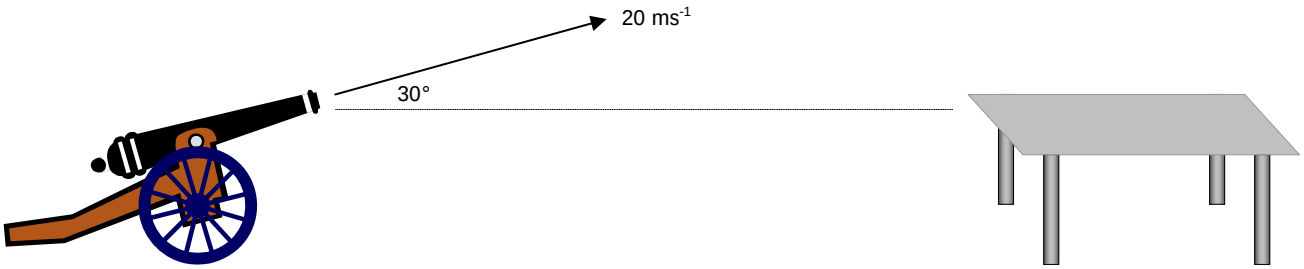
   (c) Calculate the footballer's average velocity for the run. (2)

TOTAL 10 MARKS

Homework 4 - Equations Of Motion

1. A workman on the scaffolding outside one of the science classrooms drops a wrench. A physics student, bored with the lesson, times it as it falls past the classroom window. She found that it took 0.6s to fall past the 2m tall window. Calculate the spanner's **initial** velocity as it appears at the top of the window. (2)

2. A human cannonball at a circus is fired from the cannon with a muzzle velocity of 20 ms^{-1} at 30° to the ground, and (hopefully) lands in a safety net that is at the same height as the mouth of the cannon.



(a) Calculate the horizontal and vertical components of the performer's velocity. (2)

(b) How high above the net was he at his highest point? (2)

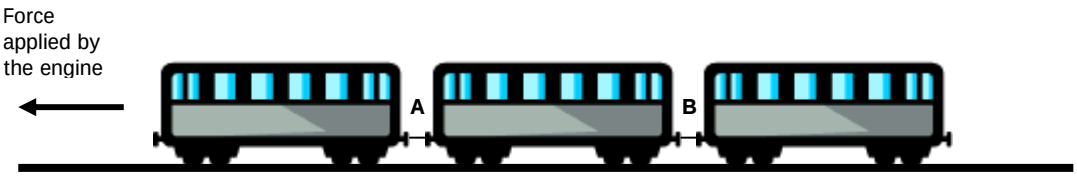
(c) How far from the cannon should the net have been placed to safely catch the performer? (3)

(d) In practice, this distance would have to be slightly shorter. Why? (1)

TOTAL 10 MARKS

Homework 5 - Forces

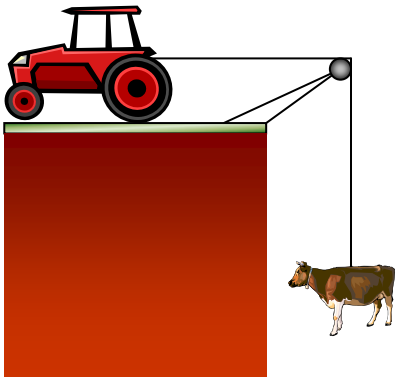
1. A train made up of 3 carriages is pulled along a level track by a force of 16 500 N. Each of the carriages has a mass of 8 000 kg, and each experiences 1500 N of resistive forces.



   (a) Calculate the acceleration of the train. (2)

   (b) Work out the tension in link **B**. (2)

2. A cow has fallen over a cliff and cannot get back up to the field. The farmer has to rescue it by attaching a rope and harness, and lifting it using a pulley and his tractor (as shown in the diagram).



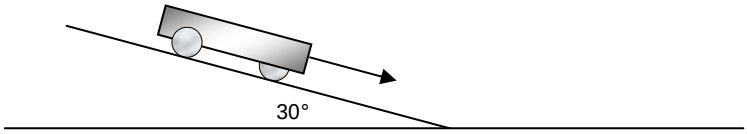
   The tractor has a mass of 1500 kg, and the cow has a mass of 500 kg. The tractor's engine can apply a force of 6000 N. Ignore friction between the tractor and the ground.

   (a) Calculate the initial acceleration of the tractor as it lifts the cow. (2)

   (b) Draw a free body diagram showing the forces acting on the cow as it is being lifted. (1)

   (c) Calculate the tension in the rope lifting the cow. (2)

3. In the diagram below, calculate the component of the weight acting down the slope. The mass of the trolley is 24 kg. (1)

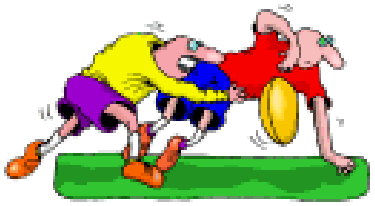


TOTAL 10 MARKS

Homework 6 - Momentum And Impulse

1. In a rugby match, a 110 kg forward in one team tackles an 85 kg back in the other team. The forward is travelling at 5 ms^{-1} and the back at 7 ms^{-1} in the opposite direction when they collide and 'stick' together.

   Take the direction of the forward as the positive direction.



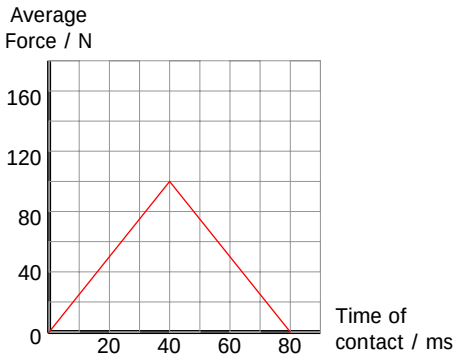
   (a) Calculate the velocity of the pair immediately after the collision. (2)

   (b) Show by calculation whether this collision is elastic or inelastic. (2)

2. Explain, in terms of forces on the driver, why a seatbelt offers a far less damaging alternative to a steering wheel when a car stops suddenly during a collision. (2)

3. In a game of squash, a ball of mass 0.1 kg is moving towards the player with a velocity of 20 ms^{-1}. She strikes it with the racquet and it returns towards the wall at 40 ms^{-1}. If the time of contact between racquet and ball is 50 ms, calculate the force applied on the ball by the racquet. (2)

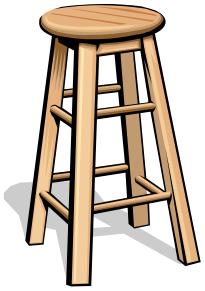
4. A golfer strikes a stationary golf ball, and the force applied by the club on the ball varies as shown in the graph below. Use this graph to determine the final speed of the golf ball. The ball's mass is 0.1 kg. (2)



TOTAL 10 MARKS

Homework 7 - Pressure And Density

1. The stools in the physics rooms have four round feet, each with a surface area of approximately 1 cm^2. The physics teachers complain that when people swing onto just one leg of the stool, the flooring under it is damaged. For the purposes of this problem, take the average mass of a pupil to be 60 kg.



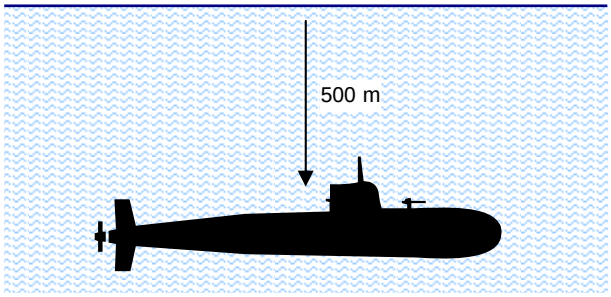
   (a) Calculate the area of one of the stool's feet in $\mathbf{m^2}$. (1)

   (b) Calculate the pressure exerted on the floor when all four feet are on the ground (as they should be!) (2)

   (c) Calculate the pressure exerted on the floor when just one foot is on the ground. (1)

2. What is the mass of a block of steel that is 2 cm x 2 cm x 2 cm? (Density of steel = 8000 kgm^{-3}) (2)

3. A submarine, mass 50 000 kg, is 500 m under the surface of a freshwater loch. The density of the water is 1000 kgm^{-3}. When the submarine's air tanks are full, it experiences an upthrust of 550 000 N.



   (a) Calculate the pressure from the water at this depth. (2)

   (b) Will the submarine rise to the surface, sink, or float at a constant depth? Explain your answer. (2)

TOTAL 10 MARKS

Homework 8 - Gas Laws

1. A car has its tyres inflated to a pressure of 240 kPa on a day when the temperature is 5 °C. The car is then driven for several hours, and the temperature of the tyres is found to have risen to 35 °C.

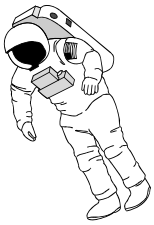
   (a) Assuming the mass and volume of the air in the tyres has remained constant, calculate the new pressure in the tyres. (2)

   (b) Explain why this happens to the pressure as the temperature rises, making reference to the kinetic theory of gases. (2)

2. In preparation for a party, a balloon is inflated to a volume of 0.5 m^3 in a cold room (0 °C). During the party, the room temperature rises to 22 °C.

   Calculate the new volume of the balloon, assuming the pressure inside it remains constant. (2)

3. An astronaut on a spacewalk has an oxygen tank strapped to his suit. The oxygen in it is pressurised to 5 atmospheres (5.0×10^5 Pa), and the volume of the tank is 15 litres.



   (a) The oxygen is pumped to his mouth at atmospheric pressure (1.0×10^5 Pa). What is the maximum volume of oxygen available to the astronaut at this pressure? (2)

   (b) What assumptions are made about the gas that allow us to perform this calculation? (1)

   (c) In reality, the astronaut would find that he had less oxygen available to him than calculated in part (a). Why would this be the case? (**Problem solving!**) (1)

TOTAL 10 MARKS

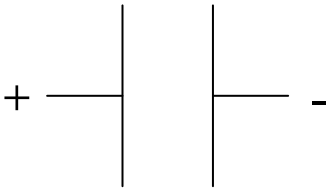
Homework 9 - Electric Fields

1. Draw the electric field around the following charges. You must show the direction of the field clearly. (3)

   (a)

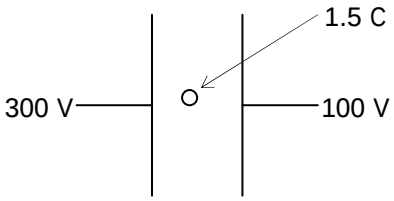
   

   (b)

2. What is the definition of a **volt**? (1)

3. Look at the following diagram.

   (a) What is the potential difference between the two plates? (1)

   (b) Calculate the work done in moving the charged particle across the electric field. (2)

4. Most vehicle assembly lines use robots to paint the vehicles being produced (as shown in the photograph to the right). Electrostatic methods of painting are used to reduce wasted paint, to ensure an even covering of the car body, and to prevent mess. The car body is given a positive charge, and the paint droplets are given a negative charge as they leave the nozzle.

   In the electrostatic painting system shown, a small droplet of paint (mass 1g) is given a charge of 2 mC before being accelerated by a potential difference of 100 V. Calculate the speed of the drop as it hits the vehicle. You can ignore the effects of air resistance for the purposes of this calculation. (3)

TOTAL 10 MARKS

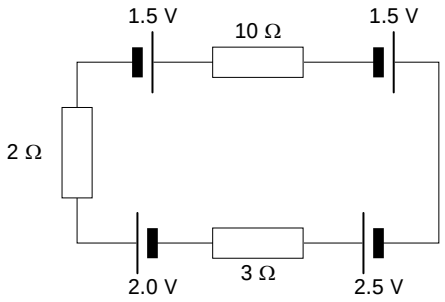
Homework 10 - Resistors, EMF & Internal Resistance

1. In the circuit below, calculate

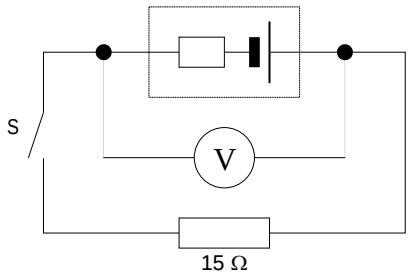
   (a) The total electrical potential energy gained by each coulomb of charge. (1)

   (b) The current through the 10 Ω resistor. (1)

   (c) The potential difference across the 10 Ω resistor. (2)



2. In the circuit below, the reading on the voltmeter is 5 V when switch **S** is open and 3 V when it is closed.

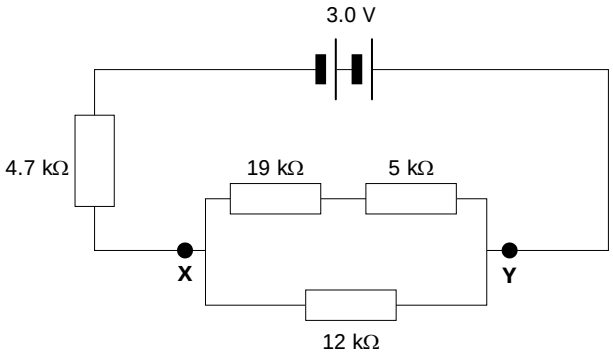


   (a) What is the EMF of the cell? (1)

   (b) Calculate the current flowing in the circuit when the switch is closed. (1)

   (c) What is the internal resistance of the cell? (2)

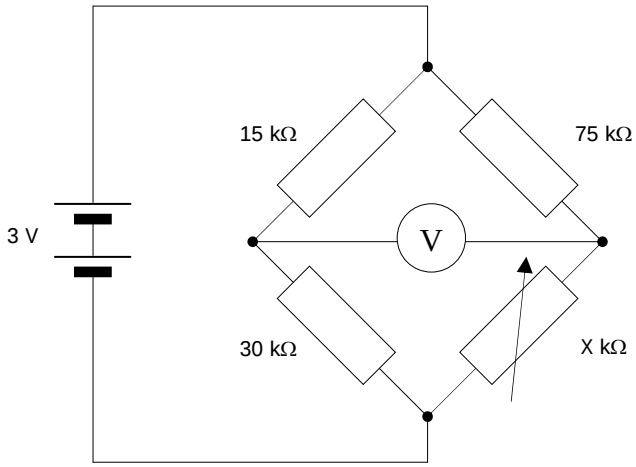
3. Calculate the equivalent resistance between **X** and **Y** in the circuit below. (2)



TOTAL 10 MARKS

Homework 11 - Wheatstone Bridges

1. The circuit below is set up in a physics lab. Variable resistor X is varied until the Wheatstone Bridge is balanced.



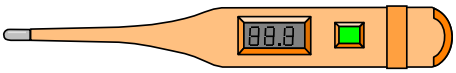
(a) What is meant by a balanced Wheatstone Bridge? (1)

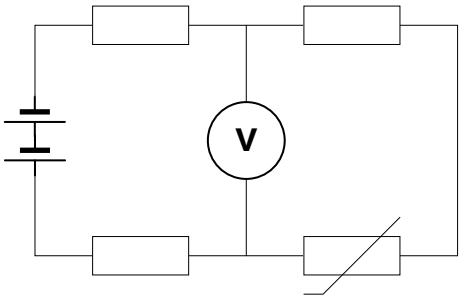
(b) Calculate the value of variable resistor X when the bridge is balanced. (2)

(c) The 3V battery is removed and replaced with a 12V battery. State and explain the effect on the reading on the Voltmeter. (2)

(d) The 3V battery is put back in place, and the variable resistor X is replaced with a 75 kΩ resistor. Calculate the reading on the voltmeter now. (3)

2. A digital thermometer uses a Wheatstone bridge circuit with a thermistor in it to measure temperature. The circuit used is shown below:





As the temperature rises, the resistance of the thermistor drops.

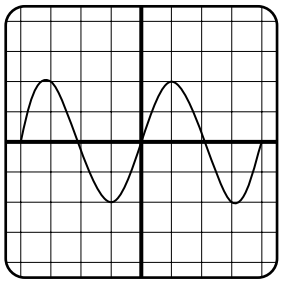
(a) Draw a graph to show how the reading on the voltmeter changes as the temperature rises. (1)

(b) Extend your graph to show what happens if the temperature drops below zero. (1)

TOTAL 10 MARKS

Homework 12 - AC & Capacitors

1. The oscilloscope below shows the potential difference over a bulb attached to an AC power supply.



The y-gain is set at 5V / div.

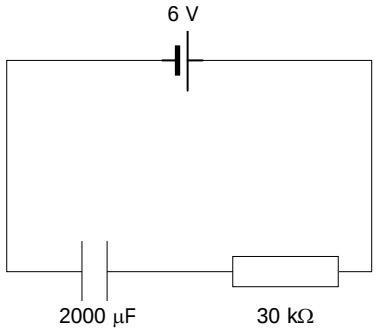
The time base is set at 5ms / div.

(a) State the peak potential difference of the trace. (1)

(b) Calculate the frequency of the supply. (2)

(c) Calculate the rms value of the potential difference. (1)

2. A physics student set up the circuit below.



(a) Calculate the charge stored by the capacitor in this circuit. (2)

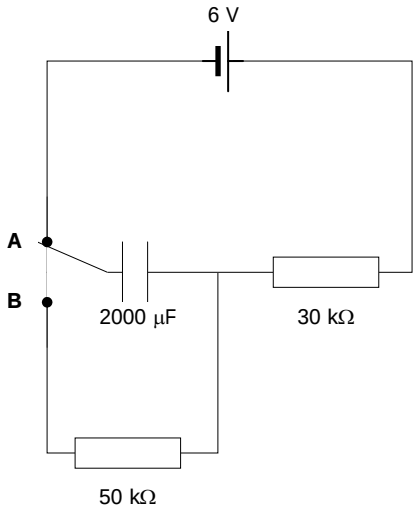
(b) Using this charge, calculate the energy stored by the capacitor. (2)

(c) The 6 V battery is replaced with a 12 V battery. Calculate the energy stored by the capacitor now. (2)

TOTAL 10 MARKS

Homework 13 - Capacitors in Circuits

1.



The circuit above is set up with the capacitor initially discharged. The switch is put to position A, and the capacitor allowed to fully charge. This process takes 60 seconds.

(a) Calculate the initial charging current in the circuit. (2)

(b) State the current once the capacitor is fully charged. (1)

(c) Draw a graph of charging current Vs time. You should have values on both axes. (2)

(d) What is the potential difference over the capacitor when it is fully charged? (1)

The switch is thrown to position B, and the capacitor is allowed to fully discharge.

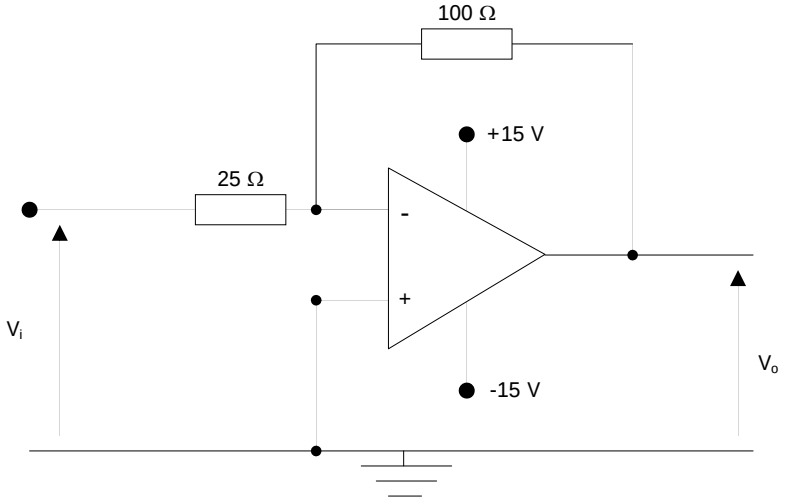
(e) Calculate the initial discharge current. (2)

(f) How would the discharge time compare to the charge time? Explain your answer. (2)

TOTAL 10 MARKS

Homework 14 - Analogue Electronics

1. The following op-amp circuit is set up for a series of experiments:



(a) Which mode is this op-amp operating in? (1)

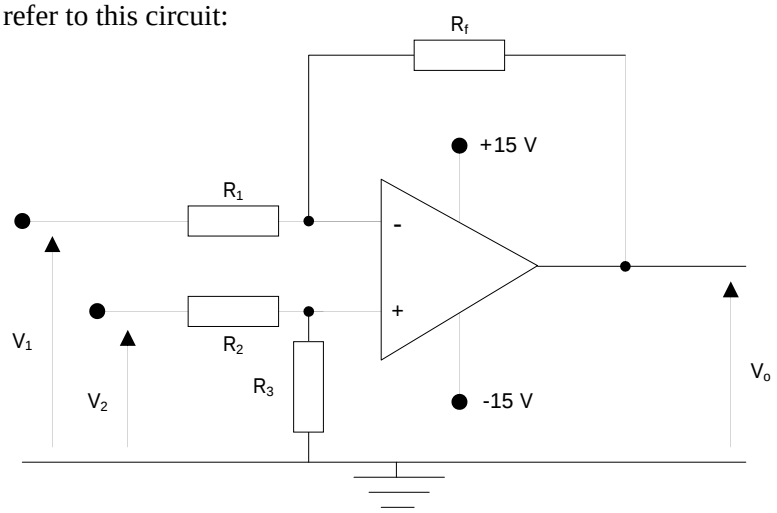
(b) State the gain equation for this op-amp. (1)

(c) Calculate the output voltage V_o for inputs of 3V and -1V. (2)

(d) V_o stops rising when it reaches a certain value. Why is this? (1)

2. State the two assumptions we make about an ideal op-amp. (2)

3. The following questions refer to this circuit:



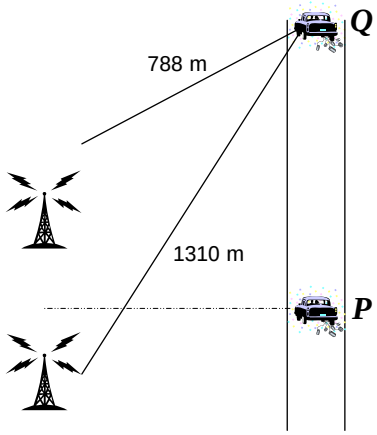
(a) State the gain expression for this mode, and give the conditions which must be met for this expression to be true. (2)

(b) The four resistors are set as follows: R_1 = 10 kΩ; R_2 = 10 kΩ; R_3 = 100 kΩ; R_f = 100 kΩ. Calculate the output voltage if V_1 = 1.25 V and V_2 = 1.35 V (1)

TOTAL 10 MARKS

Homework 15 - Waves

1. A physicist is driving home from work, listening to the radio. As she moves between two transmitters, she notices the signal getting stronger and weaker at regular intervals. The strongest signal is halfway between the two transmitters - at position ***P*** on the diagram below. As she drives north, she passes through one other maximum, and reaches a **second** maximum at position ***Q***. The distances to the two radio transmitters from this point are shown.



(a) Use the information above to calculate the wavelength of the radio waves she is listening to. (2)

(b) State and explain whether the waves from the two transmitters are in phase or out of phase at point ***Q***. (1)

2. The following equipment is set up in a darkened physics lab:

(a) Describe what is seen on the screen. (1)

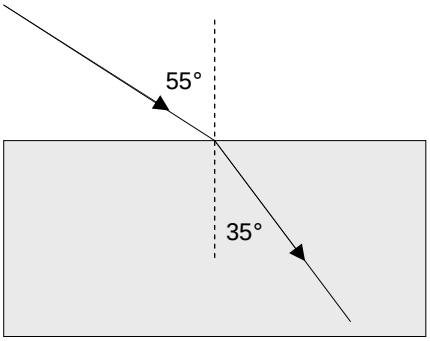
(b) The blue light source is replaced with a red light source. Describe the difference this makes to the pattern, and explain why this happens. (2)

(c) If the wavelength of the red light used is 700 nm, and the diffraction grating has 100 lines per millimetre, calculate the angle between the first order maximum and the second order maximum. (4)

TOTAL 10 MARKS

Homework 16 - Refraction of Light

1. A ray of red light has a wavelength of 700 nm in air. It is incident on a block of plastic, and is refracted as shown below:



(a) Calculate the refractive index of the block of plastic. (2)

(b) What is the wavelength of the red light in the block of plastic? (2)

(c) A blue light now replaces the red light. What happens to the angle of refraction? (1)

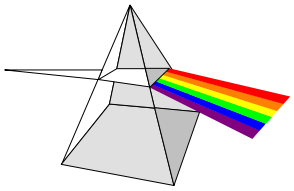
2. A physics student decides to propose to his girlfriend. Just as he is presenting the diamond engagement ring to her, he notices the sparkling is caused by total internal reflection. He is so taken by this observation, he rushes off to find out the refractive index of diamond so that he can calculate the critical angle for the diamond.

His girlfriend immediately dumped him.

(a) If the refractive index of diamond is 2.42, calculate the critical angle. (2)

(b) What is meant by 'critical angle'? (1)

3. White light is shone onto a triangular glass prism. A spectrum is viewed on the other side of the prism.



(a) Why is a spectrum produced? (1)

(b) List the colours in order from **most** deflected to **least** deflected. (1)

TOTAL 10 MARKS

Homework 17 - Optoelectronics

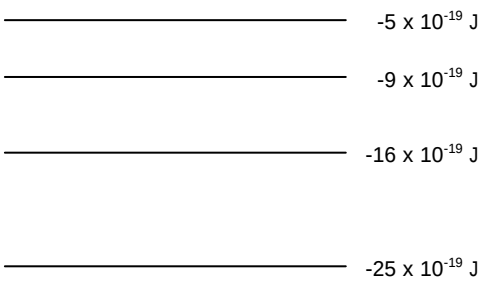
1. For a certain metal, the energy required to eject an electron from an atom is 3×10^{-19} J.

   (a) What is the minimum frequency of electromagnetic radiation required to produce the photoelectric effect with this metal? (2)

   (b) The metal is illuminated with blue light that has a wavelength of 400 nm. Show by calculation that this will cause the photoelectric effect to occur. (2)

   (c) Calculate the kinetic energy that the ejected electrons will have when the metal is illuminated with this light. (1)

2. The following diagram represents the energy levels of a particular metal's atoms.



   (a) How many possible transitions are there for this atom? (1)

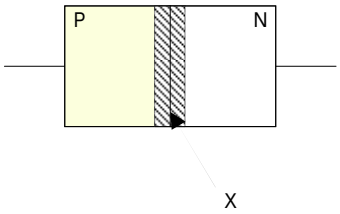
   (b) Calculate the maximum frequency of light absorbed by this atom. (2)

   (c) Which part of the spectrum would this absorption line be found in? Explain your answer. (2)

TOTAL 10 MARKS

Homework 18 - Semiconductors

1. The diagram below represents the p-n junction of a photodiode.

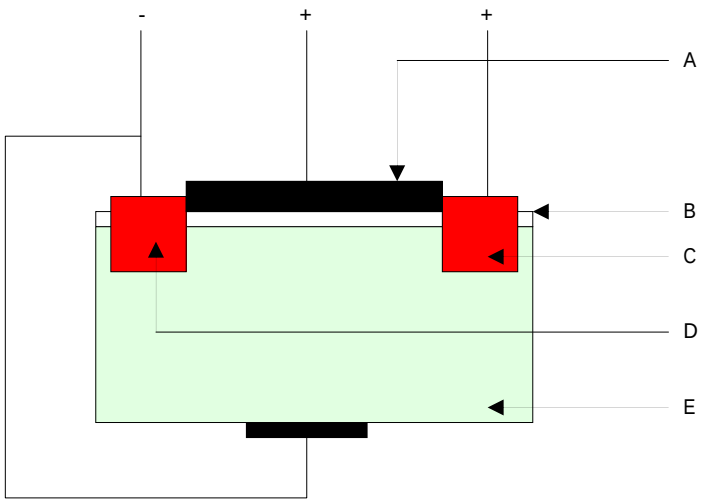


(a) State the name of the charge carriers in each type of material. (1)

(b) What name is given to the shaded region **X**, and what is special about this region? (2)

(c) The photodiode has 2 main operating modes. Name these modes, and briefly explain each of them. (3)

2. Here is a diagram of a semiconductor device.



(a) Name the device shown. (½)

(b) Copy the diagram and label the parts A to E. (2½)

(c) Explain how this device behaves in its ON state. (1)

TOTAL 10 MARKS

Homework 19 - Nuclear Reactions

1. In 1908, Rutherford carried out his famous alpha-particle scattering experiment. The particles were fired at a target, and a detector was used to determine how many of the α-particles were scattered to various positions around the target. His conclusion based on these results was that an atom must contain a nucleus.

   (a) What material did Rutherford use as the target? (1)

   (b) State the three main conclusions drawn about the nucleus. (1½)

   (c) Explain how the results of the experiment led to each of these conclusions. (1½)

2. A nuclear reaction is described by the equation below:

$$^{239}_{94}\text{Pu} + {}^{1}_{0}\text{n} \Rightarrow {}^{137}_{X}\text{Te} + {}^{Y}_{42}\text{Mo} + 3\ {}^{1}_{0}\text{n}$$

   (a) What type of reaction is this? (1)

   (b) Calculate the missing numbers ***X*** and ***Y***. (1)

   (c) Using information from the table below, calculate the energy released in this reaction. (4)

NUCLEUS / PARTICLE	MASS (U)
^{239}Pu	239.0512
^{137}Te	137.0000
^{y}Mo	99.9066
^{1}n	1.0087

(1 u = 1.66 x 10^{-27} kg)

TOTAL 10 MARKS

Homework 20 - Dosimetry & Safety

1. A technician in a nuclear power station is exposed to several types of radiation over a 150-hour working month. She receives a dose 0.2 mGy due to exposure fast neutrons, 15 μGy due to α-particles, and a dose of 1mGy from gamma rays.

   (a) Calculate the technician's total Dose Equivalent. (3)

   (b) What is her dose equivalent rate for this working period? (1)

2. Background radiation is always present, and is unavoidable.

   (a) State two sources of background radiation that we are constantly exposed to. (1)

   (b) What is the dose equivalent limit for the public in the United Kingdom over the course of a year? (1)

3. State two factors that may affect the risk of biological damage when living cells absorb radiation energy. (1)

4. A radioactive source is stored in a lead-lined box. The thickness of lead is 9.9 mm. The dose equivalent rate of the source is 16 $\mu Sv\ h^{-1}$. If lead has a half-value thickness of 3.3 mm, calculate the dose equivalent rate outside the box. (2)

5. Sketch a graph of intensity of radiation against thickness of absorber. You must label the axes. (1)

TOTAL 10 MARKS