Higher Physics

Homework Booklet

Introduction: Significant Figures and Uncertainties

Homework 1: Uncertainties

1. A student sets up a digital voltmeter and a digital ammeter to measure the voltage and current for a component in order to calculate its power. The readings are:

Voltage = 10.32V   Current = 1.45A

(a) State the reading uncertainty for each measurement.
(b) Explain why there is no need to consider random uncertainty in this experiment.
(c) Find the percentage uncertainty for each measurement.
(d) Calculate the power of the component with absolute uncertainty.

2. In an experiment to measure the average speed of a dynamics cart the cart is run down a ramp and timed using a digital stopwatch. The times recorded are:

0.34s   0.38s   0.35s   0.32s   0.35s

The ramp's length is measured with a metre stick and is found to be 91cm.

(a) State the reading uncertainty for each measurement.
(b) Calculate the random uncertainty for the time.
(c) Find the percentage uncertainty for each measurement.
(d) Calculate the average speed of the cart with absolute uncertainty

3. On a very hot day a student measures the volume of a metal cube by measuring the length of one side using a wooden ruler. He finds that the volume he obtains is larger than the manufacturer's stated value.

Give a possible systematic uncertainty in this situation which would account for this difference.

Unit 1: Our Dynamic Universe

Homework 2: Equations of Motion

1. A workman on the scaffolding outside one of the English classrooms drops a wrench. A 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 wrench's **initial** velocity as it appears at the top of the window.

2. A dragster starts at rest and accelerates to a velocity of $125ms^{-1}$ over a 2.00km track. Calculate the acceleration of the dragster.

3. A child's popper toy launches itself vertically upwards from a table with a velocity of $2.4ms^{-1}$. Calculate:

(a) The time taken for the toy to reach its maximum height above the table.

(b) The maximum height reached by the toy.

4. In Chicago during the Prohibition era, rival gangs fought to control the supply of illegal alcohol. During one skirmish, "Fats" Domingo spots one of his rivals directly below him. He hurls a brick downwards at $4.30ms^{-1}$ which hits the target 1.05 seconds later. Calculate:

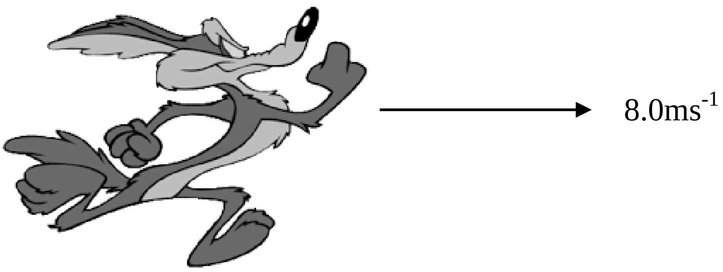
(a) How far above the target he was.

(b) The velocity at which the brick hit the unfortunate victim.

Unit 1: Our Dynamic Universe

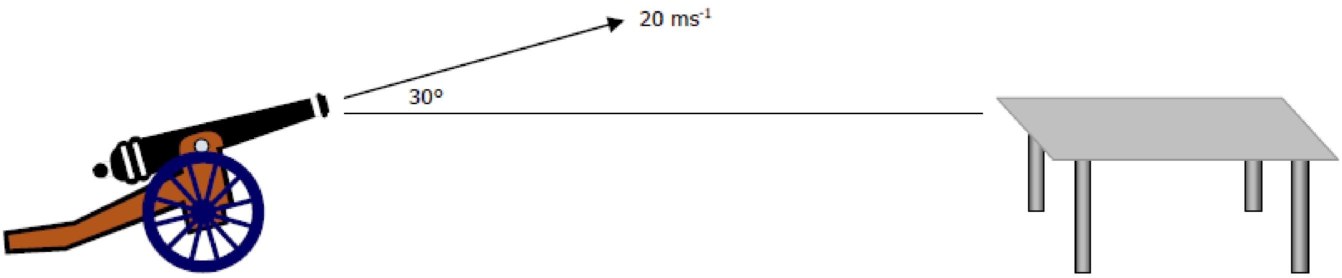
Homework 3: Projectiles

1. Wile E. Coyote runs horizontally over the edge of a cliff at $8.0 ms^{-1}$ while pursuing Roadrunner. He hits the ground 3.57 seconds later.



(a) Calculate how far he lands from the base of the cliff.
(b) Calculate the height of the cliff.
(c) Show that his vertical velocity at the point of impact with the ground is $35.0 ms^{-1}$.
(d) Hence, by scale drawing or otherwise, find the **magnitude** of his actual impact velocity.

2. A human cannonball at a circus is launched from a 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.

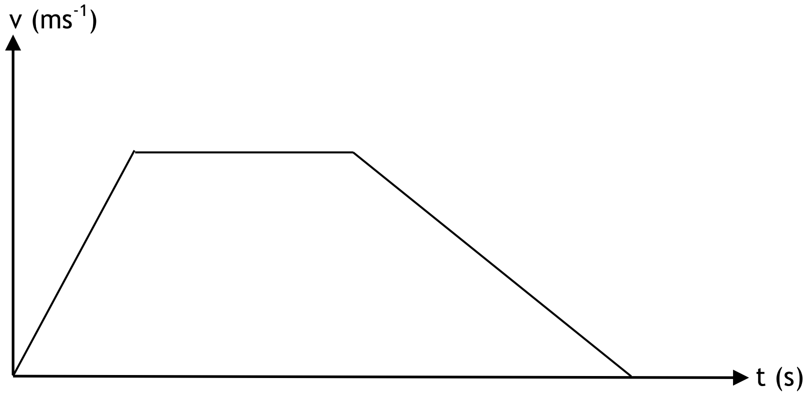


(a) Calculate the horizontal and vertical components of the performer's velocity.
(b) How high above the net was he at his highest point?
(c) How far from the cannon should the middle of the net have been placed to safely catch the performer?
(d) In reality, this distance would be slightly shorter. Explain why.

Unit 1: Our Dynamic Universe

Homework 4: Motion Graphs

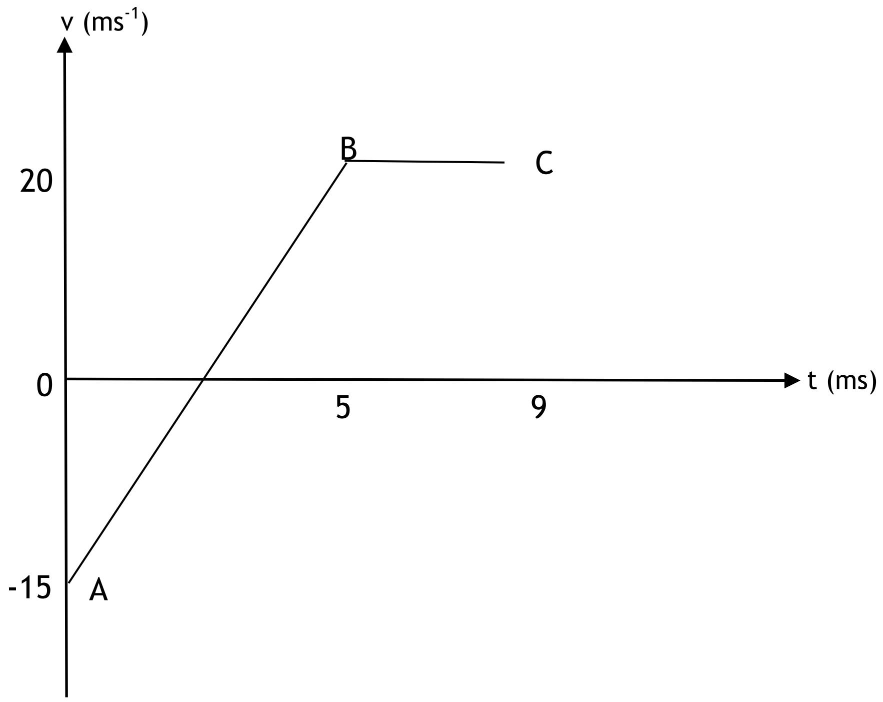
1. The graph below shows how the velocity of a car changes over a period of time.



Draw a sketch graph showing the acceleration of the car over the same period of time. Numerical values are **not** required.

2. A small stone is thrown vertically upwards by a passing car. Draw graphs showing how the acceleration and velocity of the stone change while it is in the air.

3. The graph below shows how the velocity of a squash ball changes over a period of time. AB shows the ball being struck by a racquet and BC shows the ball moving from racquet to wall.



Draw an acceleration-time graph for the squash ball. Numerical values **are** required on both axes.

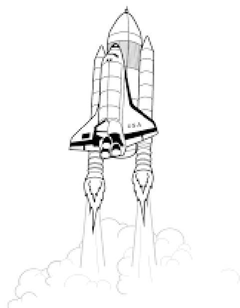
Unit 1: Our Dynamic Universe

Homework 5: Forces (1)

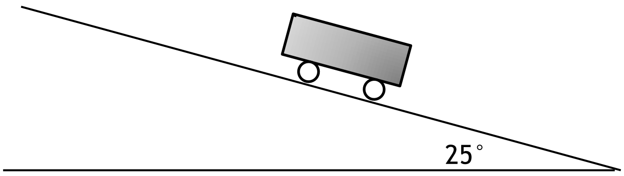
1. A 48kg box is pushed with a force of 200N to provide an acceleration of $3.5ms^{-2}$.
Calculate the average force of friction acting on the box.

2. A rocket with a mass of 6000kg uses an engine force of 3.11×10^5N during lift-off.

(a) Calculate the weight of the rocket.
(b) Calculate the acceleration of the rocket at lift-off.
(c) State any assumption you have made for part (b)
(d) As the rocket reaches the upper atmosphere its acceleration is greater than at lift-off. Give **two** reasons why this is so.
(You may assume that the engine force remains constant)



3. The diagram below shows a dynamics cart on a ramp.



The cart has a mass of 700g and there is an average frictional force of 0.93N between the cart and the ramp.

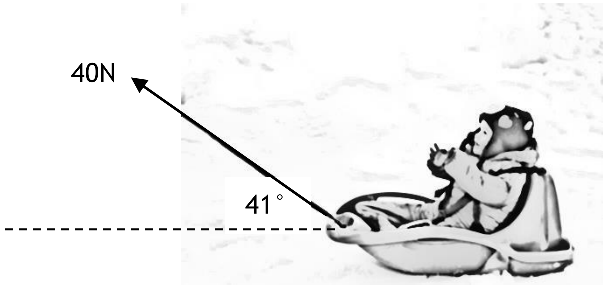
(a) Calculate the component of weight acting down the slope.
(b) Calculate the acceleration of the cart
(c) The cart starts from rest and rolls 20cm to reach the bottom of the slope. Calculate its velocity at the bottom.

4. Explain, in terms of forces, why a skydiver falling through the Earth's atmosphere will reach terminal velocity.

Unit 1: Our Dynamic Universe

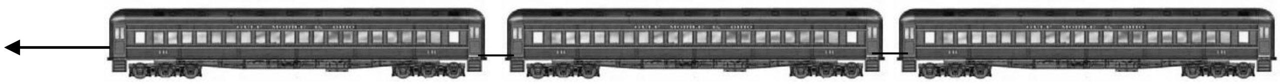
Homework 6: Forces (2)

1. A child in a sledge is pulled along using a cord as shown below:



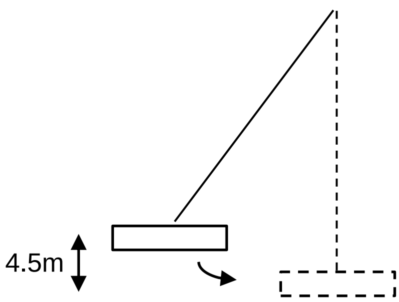
The sledge moves horizontally with an acceleration of $1.2ms^{-2}$. The mass of the sledge is 2.4kg. Calculate the mass of the child.

2. Three train carriages are linked by chains as shown below. The engine at the front supplies a forward force of 18kN. Each carriage has a mass of 9000kg and experiences a frictional force of 1200N.



(a) Calculate the acceleration of the train.
(b) Calculate the tension in the link between the 2nd and 3rd carriages.

3. A 3kg swing is dropped from a height of 4.5m as shown below.



(a) Calculate the speed of the swing as it passes the lowest point
(b) State the assumption you have made.
(c) The swing is replaced with another swing which has a larger mass. What effect will this have on the speed at the lowest point? **Explain** your answer.

Unit 1: Our Dynamic Universe

Homework 7: Momentum and Impulse

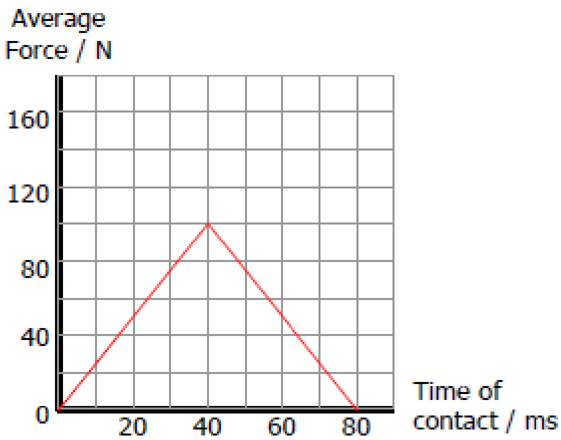
1. During a rugby match a 106kg forward running at $7ms^{-1}$ chases and tackles a 90kg back running at $5ms^{-1}$. They stick together and continue moving.

(a) Calculate the velocity at which they move after the tackle.
(b) Show by calculation whether the collision is elastic or inelastic.

2. Big Shuggy is running at $5.6ms^{-1}$ when he collides with a stationary old lady. She is thrown forwards and Shuggy rebounds at $1.1ms^{-1}$. Shuggy's mass is 90kg and the old lady's mass is 47kg.
Calculate the velocity of the old lady immediately after the collision.

3. A firework accidentally explodes while still stuck in the ground. It splits into 2 pieces. The first has a mass of 300g and flies to the left left at $23ms^{-1}$. The second flies to the right at $20ms^{-1}$.
Calculate the mass of the second piece.

4. A golfer strikes a stationary golf ball with a mass of 100g. The force applied to the ball varies as shown in the graph below.



Use the graph to determine the final velocity of the golf ball.

Unit 1: Our Dynamic Universe

Homework 8: Gravitation and Special Relativity

1. A 5000kg survey craft is orbiting the Moon at a height of 1.71×10^6m from the **centre** of the Moon. The Moon has a mass of 7.3×10^{23}kg.
Calculate the magnitude of the gravitational force between the Moon and the survey craft.

2. An astronaut on the ISS appears to be weightless when viewed on a screen during a satellite link up, even though they are still within the Earth's gravitational field.
Explain this phenomenon.

3. A student writes the following note in their book:

"A light beam in a moving train will appear to move faster to an observer standing outside the train"

Explain why this statement is incorrect and what the observer would actually see.

4. An experiment is carried out on a space shuttle moving at 1.9×10^8 ms^{-1}. The time taken for an event to happen is measured on the shuttle as 12.5s and the length of an object is measured to be 20cm.

(a) Calculate the time which an observer on Earth would measure for the same event.

(b) Calculate the length which an observer on Earth would measure for the same object.

Unit 1: Our Dynamic Universe

Homework 9: The Expanding Universe

1. An ambulance with its siren operating approaches a stationary observer at $27ms^{-1}$. The siren's sound has a frequency of 700Hz. What is the frequency of the sound perceived by the observer? (Speed of sound in air = $340ms^{-1}$)

2. An astronomer measures the velocity of a distant galaxy and finds that it is moving away from our galaxy at a velocity of 4.00×10^6 ms^{-1}.

(a) Calculate the redshift ratio for this galaxy.

(b) Calculate the distance between the two galaxies. Give your answer in Light-years. (Use 2.34×10^{-18} s^{-1} for Hubble's constant)

3. Explain how Hubble's observations show that the Universe is expanding.

4. State what is meant by a "Blackbody"

5. Two stars are studied by astronomers. Star A is found to have a peak wavelength at 430nm and Star B has a peak wavelength at 1200nm.

(a) Explain which of these stars is hotter.

(b) Use Wien's Law to calculate the surface temperature of Star B.

6. (a) Explain what is meant by "The Big Bang".

(b) Give two examples of evidence for the Big Bang.

Unit 2: Particles and Waves

Homework 10: The Standard Model

1. Describe the Bohr model of the atom.

2. Explain what is meant by "anti-matter".

3. For each of the particles below, determine the charge from its quark make-up.

(a) Xi	Down Strange Strange (dss)
(b) Bottom Lambda	Up Down Bottom (udb)
(c) D Meson	Charm Anti-Up ($c\bar{u}$)

4. Explain the difference between a baryon and a meson.

5. Explain the difference between a fermion and a boson.

6. Name the four fundamental forces and their exchange particles.

Unit 2: Particles and Waves

Homework 11: Charged Particles

1. State what is meant by a potential difference of 1 volt.

2. Two parallel plates are connected to a power supply so that one is positively charged and the other is negatively charged. The potential difference between the plates is 1.5kV.

(a) Draw a diagram showing the electric field between the two plates.

(b) A particle with a mass of 1.6×10^{-6} kg and a charge of +300μC is released from the positive plate. Calculate the work done to move the particle through the electric field.

(c) Calculate the velocity of the particle as it reaches the negative plate.

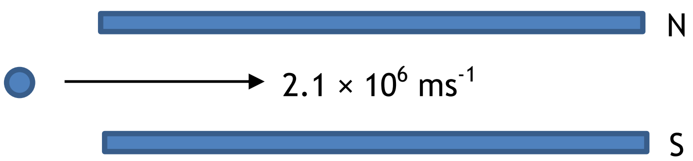
(d) The plates are repositioned so that they are closer together and another particle, identical to the first, is released from the positive plate. **Explain** how the velocity of this particle will compare to the previous particle.

3. Draw diagrams showing the directions of the magnetic fields around wires which are carrying conventional current

(a) Into the page

(b) Out of the page

4. An electron enters a magnetic field with a velocity of 2.1×10^{6} ms^{-1} as shown in the diagram below.



(a) Calculate the potential difference used to accelerate the electron to this velocity.

(b) State the direction in which the electron is deflected when it enters the magnetic field.

Unit 2: Particles and Waves

Homework 12: Nuclear Reactions

1. **(a)** Two isotopes of carbon are carbon-12 and carbon-14. Write these isotopes as chemical symbols.
   (b) State what makes these two isotopes different from each other.
   (c) Carbon-12 has a mass of 1.9926×10^{-26} kg. Calculate the binding energy of this atom.

2. For each of the following decay equations identify the symbols or numbers represented by the letters a – f and X – Z.

   (a) ${}^{222}_{86}Rn \rightarrow {}^{218}_{84}Po + {}^{a}_{b}X$ **(b)** ${}^{210}_{83}Bi \rightarrow {}^{210}_{84}Po + {}^{c}_{d}Y$ **(c)** ${}^{234}_{92}U \rightarrow {}^{e}_{f}Z + {}^{4}_{2}\alpha$

3. Describe what is meant by nuclear fission and nuclear fusion.

4. Inside a nuclear reactor the following reaction occurs:

$${}^{235}_{92}U + {}^{1}_{0}n \rightarrow {}^{144}_{56}Ba + {}^{89}_{36}Kr + 2{}^{1}_{0}n$$

   Use the data below to calculate the energy released in this reaction.

<u>Atomic Masses (kg)</u>

${}^{235}_{92}U$	3.90300×10^{-25}	${}^{89}_{36}Kr$	1.47651×10^{-25}
${}^{144}_{56}Ba$	2.38990×10^{-25}	${}^{1}_{0}n$	1.67492×10^{-27}

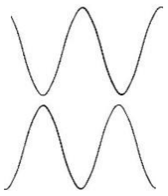
5. **(a)** In a nuclear reactor, state the purpose of the *moderator* and *control rods*.
   (b) Explain what would happen if the control rods were not present.

Unit 2: Particles and Waves

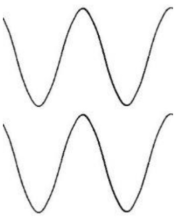
Homework 13: Interference and Diffraction

1. For each pair of waves below, state (i) the type of interference produced and (ii) the phase difference between the two waves

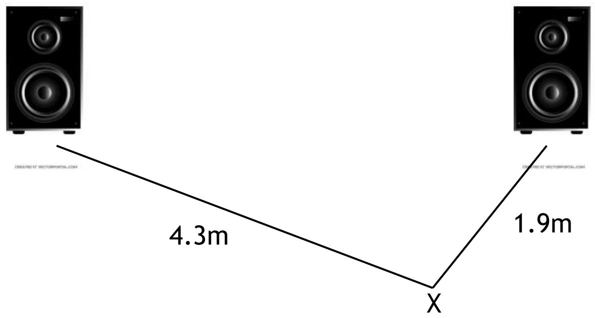
(a)



(b)



2.

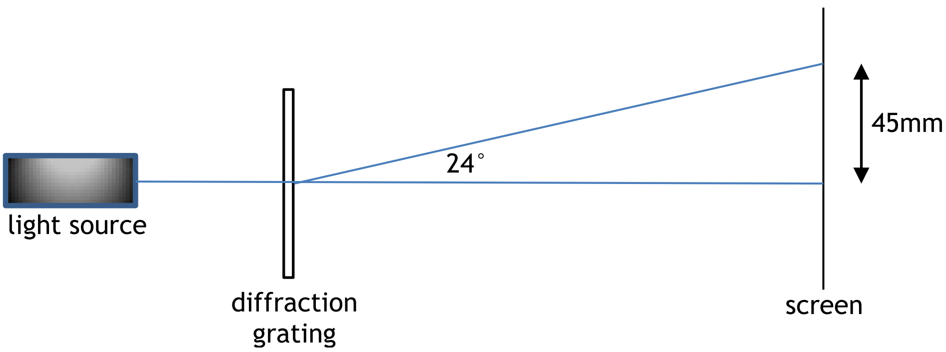


An investigation to find the wavelength of a sound wave is carried out. A point of maximum sound level is recorded exactly halfway between the two speakers. The second maximum point is found at X, as shown.

Calculate the wavelength of the sound wave.

3. Red light with a wavelength of 630nm is passed through a diffraction grating with 400 lines per mm.
   (a) Calculate the slit separation for the diffraction grating.
   (b) Calculate the angle between the zero and third order maxima.

4. The experiment below is used to measure the wavelength of a monochromatic light source. The angle shown is to the second order maximum and a grating with 500 lines per mm is used.

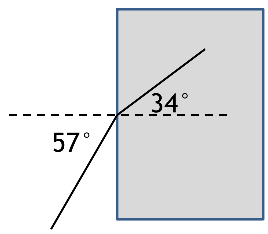


   (a) Calculate the wavelength of the light.
   (b) State the colour of the light from the source.
   (c) Calculate the distance from the grating to the screen

Unit 2: Particles and Waves

Homework 14: Refraction

1. Calculate the refractive index of the material shown in the diagram.



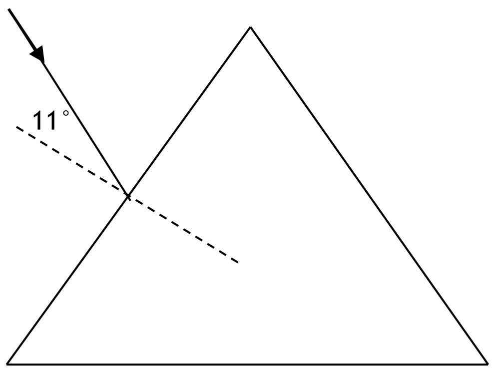
2. A laser is used to shine red light with a wavelength of 650nm into a plastic block with a refractive index of 1.45. The incident beam makes an angle of 20° with the surface of the block.

(a) Calculate the angle of refraction inside the block.
(b) Calculate the wavelength of the light inside the block.
(c) Calculate the velocity of the light in the block.

3. The critical angle for flint glass is 38.7°

(a) State what is meant by the term "critical angle".
(b) Calculate the refractive index of flint glass.

4. The diagram below shows an equilateral prism with a refractive index of 1.51.
Copy the diagram and complete the path of the ray of light, showing where it leaves the prism. You should include the values of any relevant angles on your diagram.



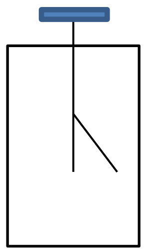
Unit 2: Particles and Waves

Homework 15: Wave – Particle Duality

1. Calculate the energy of a photon of light with a wavelength of 470nm.

2. **(a)** Calculate the wavelength of a photon which has an energy of 9.47×10^{-19}J.
(b) To which part of the electromagnetic spectrum does this photon belong?

3.



The gold leaf electroscope shown on the left is **negatively** charged.
The threshold frequency for the metal plate is 6.0×10^{15} Hz.
Bright white light is shone onto the plate. The gold leaf stays up.

(a) **Explain** how the incident radiation should be changed to make the leaf fall.

(b) The experiment is repeated using a **positively** charged electroscope. **Explain** what will happen this time.

4. The work function for a metal is 7.96×10^{-19}J.
(a) Calculate the threshold frequency for this metal.
(b) A photon with a wavelength of 120nm is incident on the metal. Calculate the kinetic energy of the electron emitted.
(c) Hence calculate the speed of the electron as it leaves the surface of the metal.

Unit 2: Particles and Waves

Homework 16: Spectra

1. Calculate the irradiance of a laser with a power of 0.3 W incident on a flat surface with an area of 5 mm^2.

2. The irradiance of a filament bulb is measured to be 40 Wm^{-2} at a distance of 2 m from the bulb. Calculate how far away the bulb would need to be to lower this irradiance to 10 Wm^{-2}.

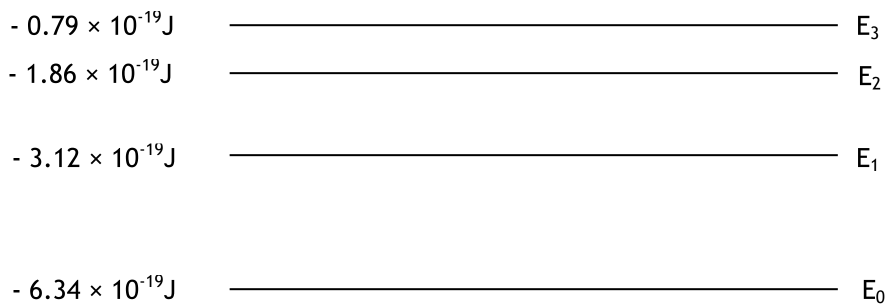
3. A diffraction grating is used to examine light from a filament bulb and a sodium lamp. Describe the spectra which each light source will produce.

4. (a) Draw a diagram showing Thompson's "plum pudding" model of the atom.

(b) Rutherford's experiment showed that the Thompson model of the atom could not be correct. Describe this experiment and its findings.

(c) Explain how Bohr's adaptation of the Rutherford model explains the emission spectrum of an element.

5. The energy levels for a specific atom are shown below.



(a) State the number of possible transitions which would produce a photon of electromagnetic radiation.

(b) Calculate the frequency of the photon produced by an electron moving from E_2 to E_0.

(c) By considering the wavelength, state the colour of the light caused by this transition.

(d) A photon of light with a wavelength of 358nm is incident on the atom. Show by calculation which transition is caused by the absorption of this photon.

Unit 3: Electricity

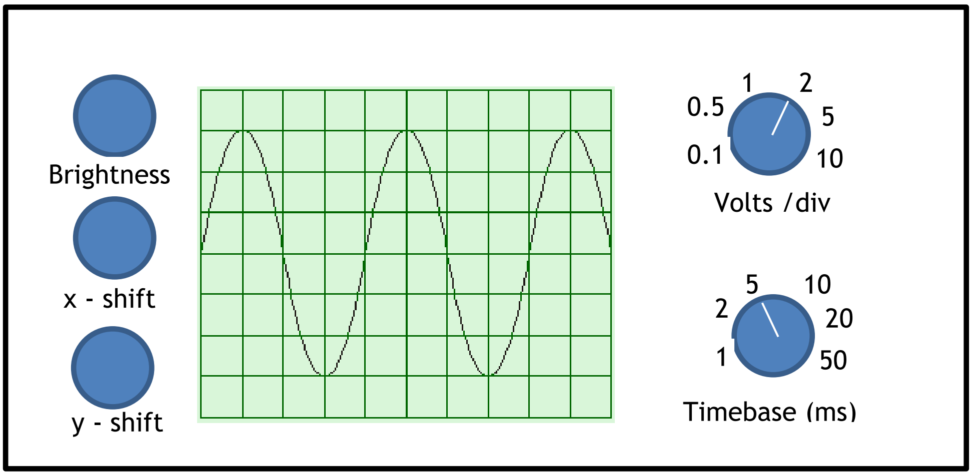
Homework 17: Alternating Current

1. State the difference between direct current and alternating current.

2. Describe a method used to generate an alternating current.

3. A toaster is connected to the mains supply and draws an r.m.s. current of 7. 3A.
(a) Calculate the peak value of the current.
(b) Calculate the resistance of the toaster.

4. The diagram below shows an oscilloscope used to investigate a supply of alternating current.



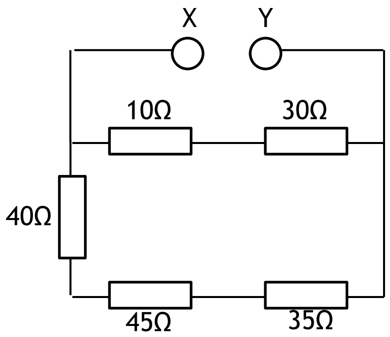
(a) Find the peak voltage of the supply.
(b) Calculate the rms voltage of the supply.
(c) Find the period of the current.
(d) Calculate the frequency of the current.

Unit 3: Electricity

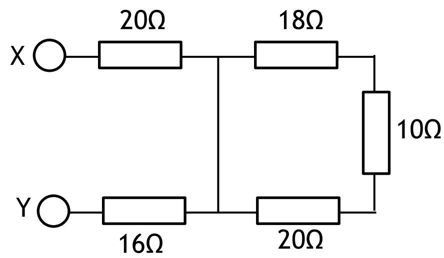
Homework 18: Circuits

1. Calculate the effective resistance between points X and Y in the diagrams below:

(a)

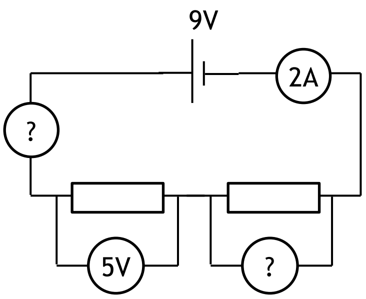


(b)

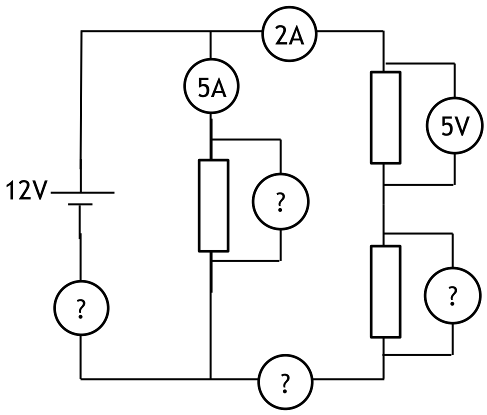


2. For each of the circuits shown below, find the missing values of the ammeters and voltmeters.

(a)

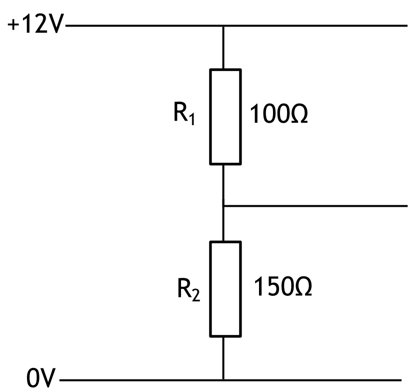


(b)



3. An LED rated at 1.4V, 150mA is connected to a 3V battery. A resistor is connected in series to allow the LED to operate at the rated values.
(a) Calculate the resistance of the resistor.
(b) Calculate the power developed by the LED.

4. Calculate the voltage across resistor R_2 in this circuit.

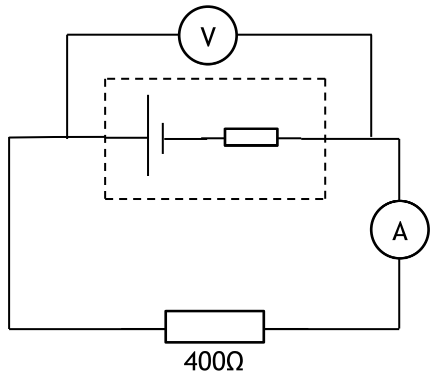


Unit 3: Electricity

Homework 19: Internal Resistance

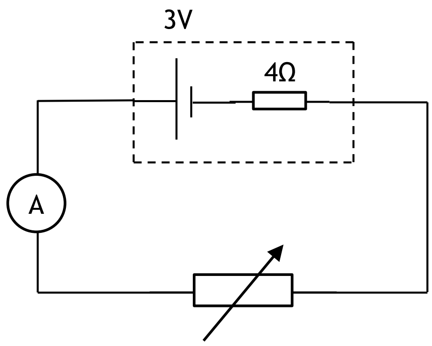
1. State the meanings of the following terms:
(a) *e.m.f.* **(b)** *t.p.d.* **(c)** *internal resistance*

2. In this circuit, the voltmeter reads 9.0V when nothing is connected to the battery.
When the load resistor is connected the ammeter reads 2.0mA.



(a) State the emf of the battery.
(b) Calculate the tpd when connected.
(c) Calculate the internal resistance of the battery

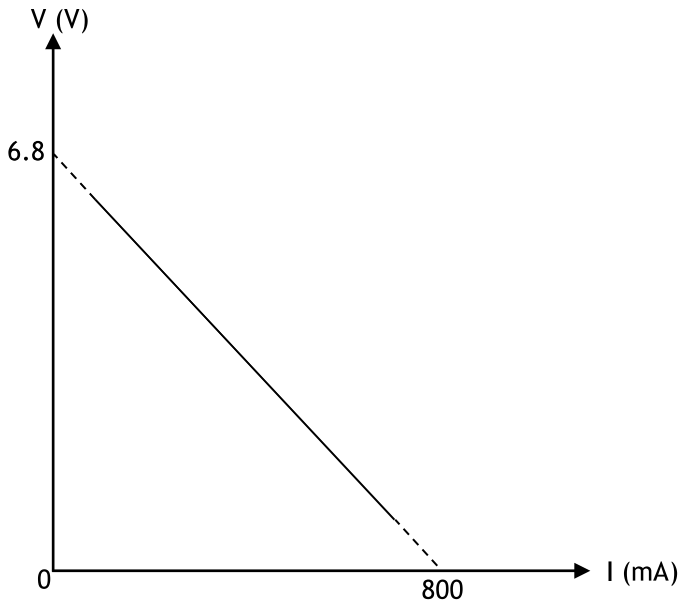
3.



In this circuit the ammeter reads 150mA.

(a) Calculate the resistance of the variable resistor.
(b) A voltmeter is connected across the battery and a reading is taken. The variable resistor is then turned up.
Explain how this affects the readings on *both* meters.

4. A circuit similar to question 3 is used to investigate internal resistance. The external load is varied and a series of readings taken. A graph of voltage against current is drawn.



From the graph find:

(a) the short circuit current.
(b) the emf of the battery.
(c) the internal resistance of the battery

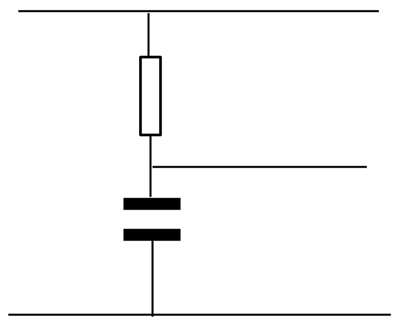
Unit 3: Electricity

Homework 20: Capacitors

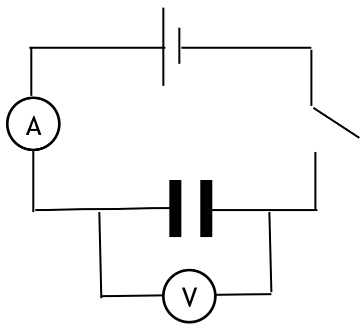
1. A 220 μF capacitor is connected to a 9V battery. Calculate the charge stored.

2. Draw graphs of voltage and current against time for a capacitor in a d.c. circuit when it is
(a) charging **(b)** discharging

3. The connection shown is used to provide a time delay for a traffic light system.
State **two** changes which could be made to this connection which would **increase** the length of the time delay.



4. In the circuit shown, the switch is closed for 20 seconds and an average current of 30mA flows. The voltmeter reads 4.7V after 20s.



(a) Show that the capacitor has stored 0.6C of charge.
(b) Calculate the capacitance of the capacitor
(c) Calculate the energy stored by the capacitor.

5. A 10mF capacitor is used to store energy in a mobile phone. The capacitor stores 30mC of charge.
(a) Calculate the voltage across the capacitor.
(b) Calculate the energy stored by the capacitor.
(c) Draw a graph showing how the charge stored varies with the voltage across the capacitor.

Unit 3: Electricity

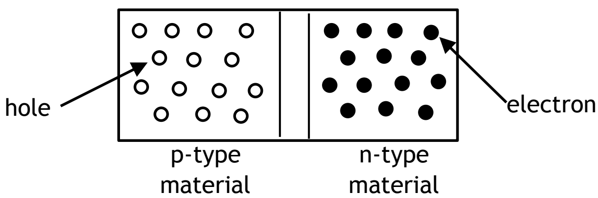
Homework 21: Semiconductors and p-n Junctions

1. When atoms are brought together in a material, state what is meant by:
(a) the valence band
(b) the conduction band

2. Draw diagrams showing the difference between the valance band and conduction band in a conductor, a semiconductor and an insulator.

3. Describe how silicon is turned into a p-type and an n-type semiconductor.

4. The diagram below shows a p-n junction.



(a) State the name of the region formed between the p-type and n-type materials.
(b) Explain how this region is formed.

5. The diagram on the right shows a p-n junction connected to a power supply.

(a) State whether this is forward or reverse biased.
(b) This is being used as an LED. Explain why the LED emits light.