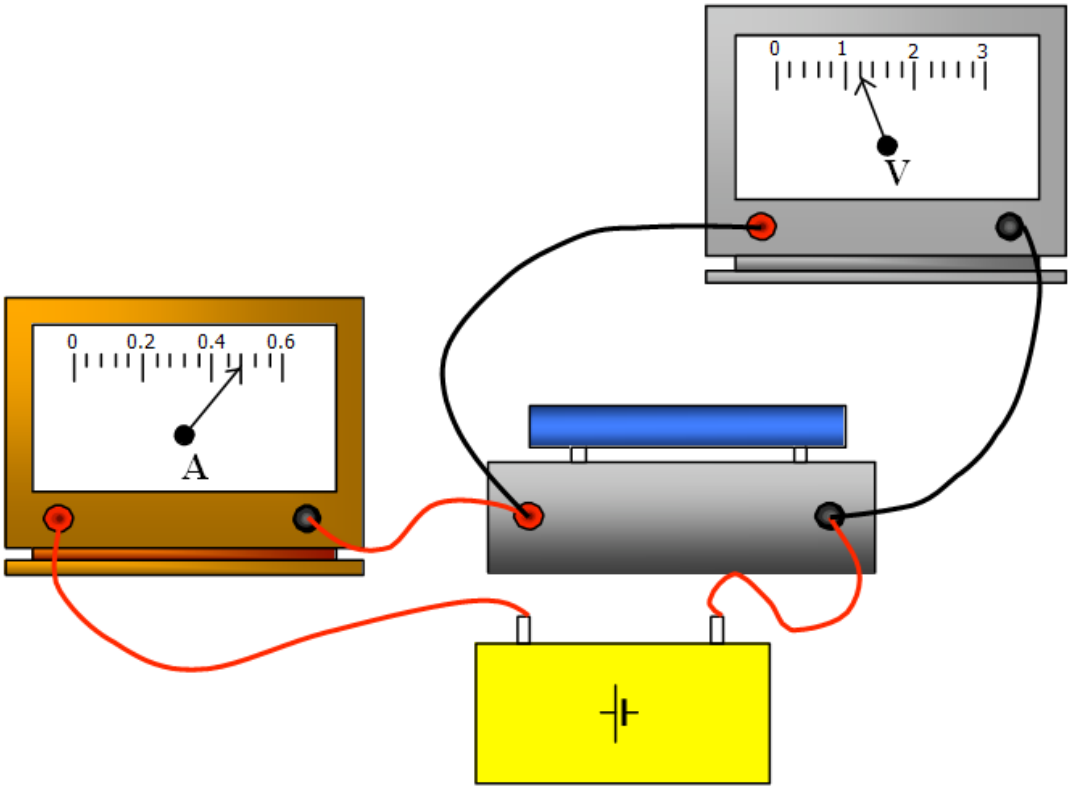
Higher Physics

Study Question Pack

Sheet 0: 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.

(4)

(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.

(5)

(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.

(4)

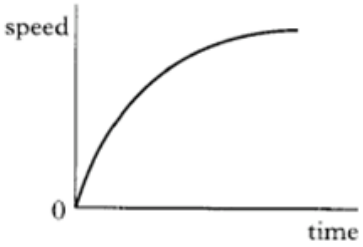
2. A current is measured with an analogue meter which has scale divisions of 0.1 A, and is found to be 5.4 A. The reading is double-checked with a digital meter, and again is found to be 5.4 A. Using which instrument gives the larger scale reading uncertainty? Explain your answer.

(7)

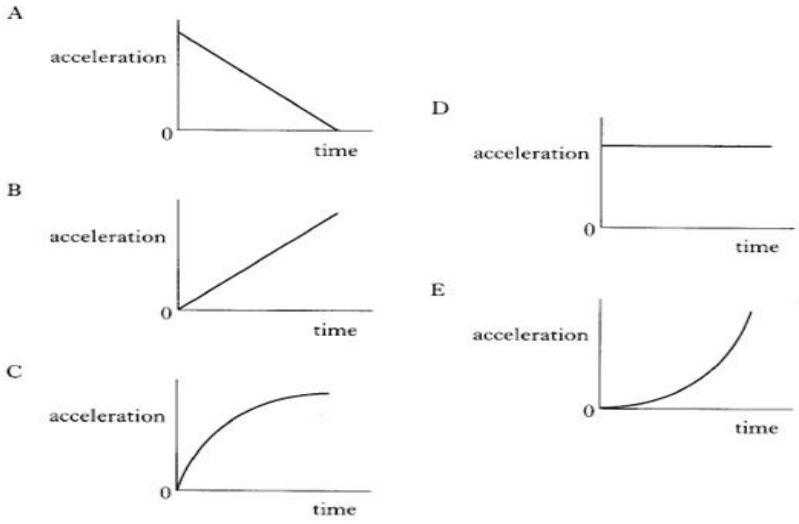
Total 20 marks

Sheet 1.1 Our Dynamic Universe: Motion - Equations and Graphs

1. The following is speed-time graph of the beginning of a cyclist's journey along a straight track.



Which of the following could be the corresponding acceleration-time graph for the same period?



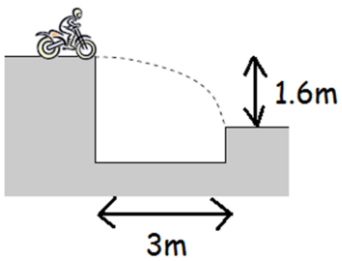
(1)

2. A ball is thrown vertically upwards with an initial velocity of 16 ms^{-1}. At its maximum height the vertical velocity of the ball is zero. Calculate:

(a) the time taken for the ball to reach its maximum height (3)

(b) the maximum height the ball reaches (3)

3. A motorcycle stunt man must drive over a 3 m pit and land on the other side safely. To complete the stunt he must calculate the minimum speed at which he needs to leave the upper platform which is 1.6 m above the landing platform. Assume he leaves this platform traveling horizontally. Calculate:



(a) the time he spends in the air (3)

(b) the minimum allowable speed he must take off at (3)

(c) express the result for (b) in km/h (2)

Total 14 marks

Sheet 1.2a Our Dynamic Universe: Forces, energy and power

1. A sledge is pulled a distance of 8 m in a straight line along a horizontal surface.

The tension in the rope is 75 N and the angle between the rope and the horizontal surface is 28°. Which row in the following table is correct?

	Horizontal component of tension /N	Vertical component of tension /N	Work done by rope /J
A	75 sin 28°	75 sin 62°	600
B	75 cos 28°	75 sin 28°	530
C	75 sin 62°	75 sin 28°	600
D	75 cos 28°	75 sin 62°	600
E	75 sin 28°	75 cos 28°	35

(1)

2. A rocket engine produces 500 N of thrust. The total mass of the rocket is 40 kg. At one point during its flight, the frictional forces acting on the rocket are 50 N. Calculate:

(a) the weight of the rocket (3)

(b) the unbalanced force acting on the rocket (1)

(c) the acceleration of the rocket. (3)

3. A group of dieting physicists are discussing shortcuts to losing weight by standing on scales in a lift. In each of the following, state and explain whether the reading on the scales will be greater then, less than or the same as their true weight.

(a) The lift is moving upwards and accelerating (2)

(b) the lift is moving upwards at a constant velocity (2)

(c) the lift is moving upwards and decelerating (2)

(d) the lift is stationary (2)

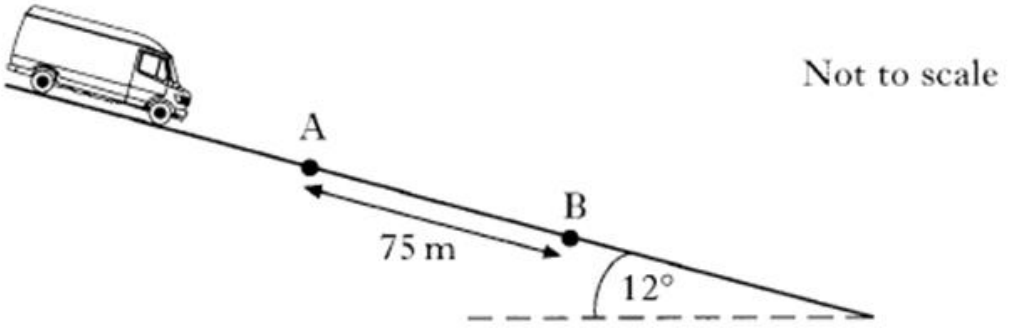
(e) the lift is moving downwards and accelerating (2)

(f) the lift is moving downwards at a constant velocity (2)

Total 20 marks

Sheet 1.2b Our Dynamic Universe: Forces, energy and power

1. A van of mass 2600 kg moves down a slope which is inclined at 12° to the horizontal as shown.

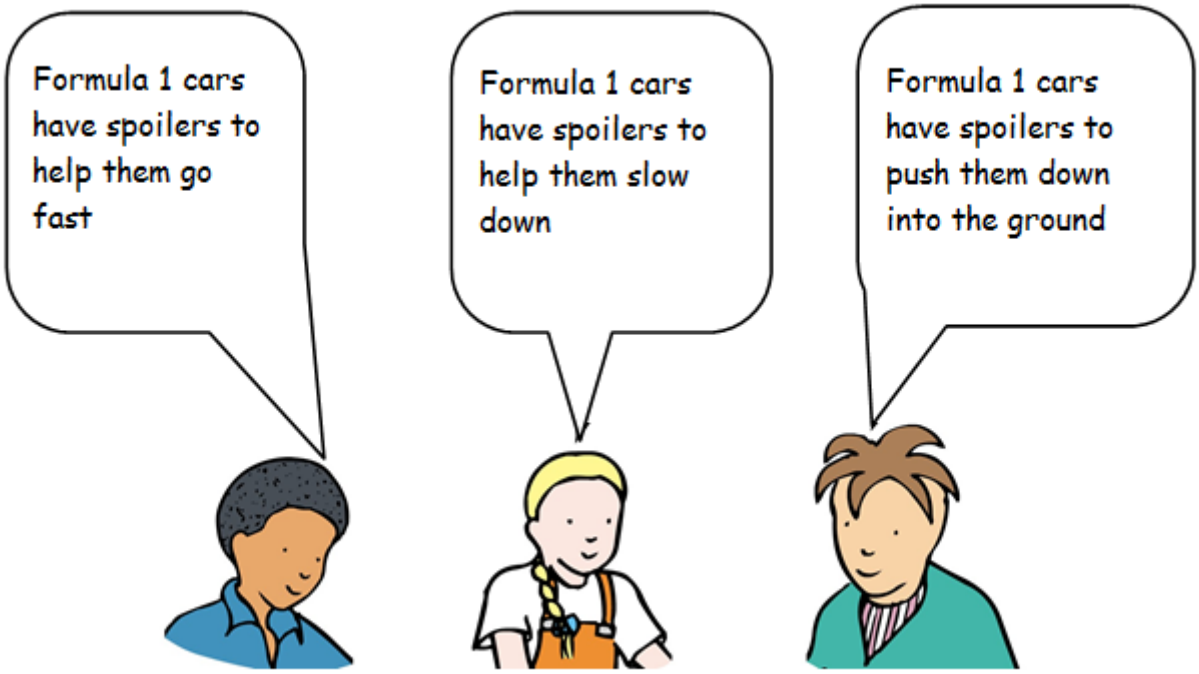


(a) Calculate the component of the van's weight parallel to the slope. (3)

(b) A constant frictional force of 1400 N acts on the van as it moves down the slope. Calculate the acceleration of the van. (4)

(c) The speed of the van as it passes point **A** is 5.0 ms^{-1}. Point **B** is 75 m further down the slope. Calculate the kinetic energy of the van at **B**. (6)

2. Use your knowledge of physics to help this group of pupils discussing the spoiler on the rear of a car.



(3)

Total (16)

Sheet 1.3a Our Dynamic Universe: Collisions, explosions and impulse

1. Car companies fit airbags which inflate automatically during an accident.

The purpose of the airbag is to protect the driver by

A reducing his change of momentum per second

B increasing his change of momentum per second

C reducing his final velocity

D reducing his total change in momentum

E increasing his total change in momentum (1)

2. A runaway train carriage has rolled down the hill and then collides with a stationary carriage at a velocity of 3 ms^{-1}. After the collision the runaway carriage is still moving in the same direction, but has been slowed to 1.5 ms^{-1}. The runaway carriage has a mass of 6000 kg, while the carriage which was hit had double this mass.

Calculate the velocity of the second carriage after the collision. Also, ascertain whether or not this collision was elastic. (8)

3. An accident in space has left an astronaut floating away from his space station at a velocity of 0.1 ms^{-1}. Having been trained in the theories of momentum he decides to use the spanner in his hand which has a mass of 2 kg. The mass of the astronaut not including the spanner is 100 kg. The astronaut throws the spanner away from the space station, which alters his own velocity.

At what velocity would the astronaut need to throw the spanner to alter his velocity to 0.1 ms^{-1} back towards the station?

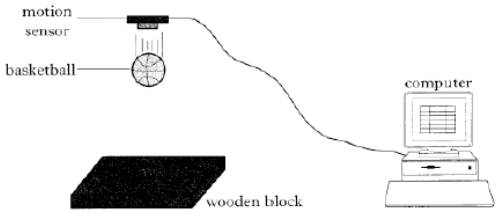
(4)

4. 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. (3)

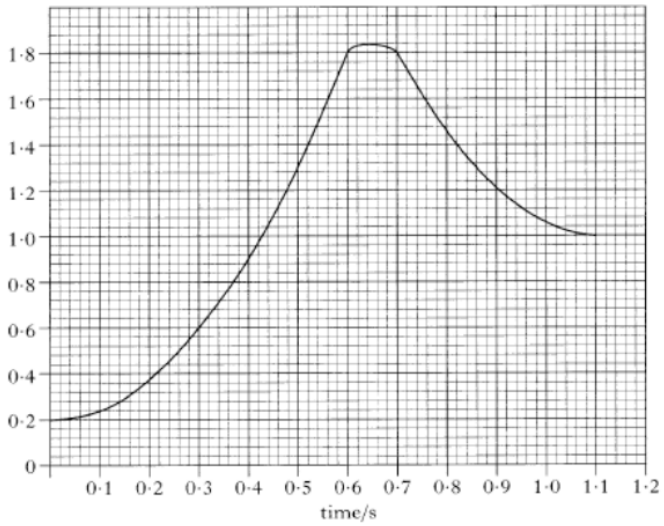
Total 16 marks

Sheet 1.3b Our Dynamic Universe: Collisions, explosions and impulse

1. A basketball is held below a motion sensor. The basketball is released from rest and falls onto a wooden block. The motion sensor is connected to a computer so that graphs of the motion of the basketball can be displayed.



A displacement-time graph for the motion of the basketball from the instant of its release is shown.



(a) (i) What is the distance between the motion sensor and the top of the basketball when it is released?

(ii) How far does the basketball fall before it hits the wooden block?

(iii) Show, by calculation, the acceleration of the basketball as it falls? (5)

(b) The basketball is now dropped several times from the same height. The following values are obtained for the acceleration of the basketball.

8.9 ms^{-2} 9.1 ms^{-2} 8.4 ms^{-2} 8.5 ms^{-2} 9.0 ms^{-2}

Calculate:

(i) the mean of these values;

(ii) the approximate random uncertainty in the mean. (3)

(c) The wooden block is replaced by a block of sponge of the same dimensions. The experiment is repeated and a new graph obtained. Describe and explain any two differences between this graph and the original graph.

(4)

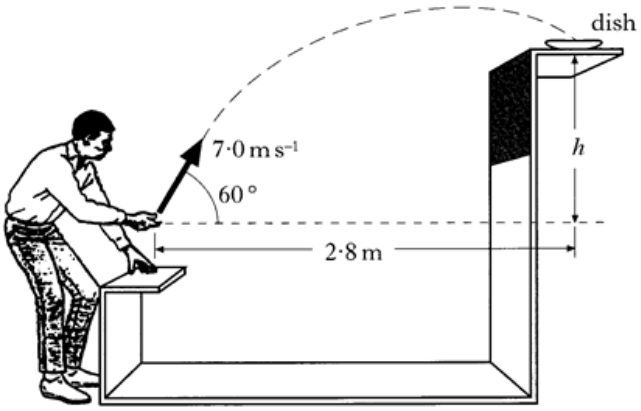
2. Using books, the internet or you tube videos, find out what happens when galaxies collide.

Write a short paragraph detailing what you have found out. (3)

Total 15 marks

Sheet 1.4a Our Dynamic Universe: Gravitation

1. At a funfair, a prize is awarded if a coin is tossed into a small dish. The dish is mounted on a shelf above the ground as shown.



A contestant projects the coin with a speed of 7.0 ms^{-1} at an angle of 60° to the horizontal. When the coin leaves his hand, the horizontal distance between the coin and the dish is 2.8 m. The coin lands in the dish. The effect of air friction on the coin may be neglected.

(a) Calculate:

(i) the horizontal component of the initial velocity of the coin; (2)

(ii) the vertical component of the initial velocity of the coin. (2)

(b) Show that the time taken for the coin to reach the dish is 0.8 s. (3)

(c) What is the height, h, of the shelf above the point where the coin leaves the contestant's hand? (3)

(d) How does the value of the kinetic energy of the coin when it enters the dish compare with the kinetic energy of the coin just as it leaves the contestant's hand? Justify your answer. (2)

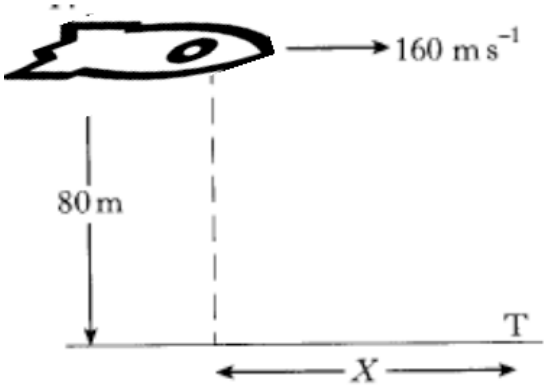
2. 'Therefore, it may be concluded that if 2 objects are dropped simultaneously from the same height, the heavier object, having a greater acceleration, will reach the ground first'.

Use your knowledge of physics to comment on the above statements (3)

Total 15 marks

Sheet 1.4b Our Dynamic Universe: Gravitation

1. An unmanned craft is flying at 160 ms^{-1} in a level flight 80 m above a planet surface. It releases a package at a horizontal distance X from the target.



The effect of air resistance can be neglected. The acceleration due to gravity on this planet is 4 ms^{-2}. The package will score a direct hit on the target T is X is

A 1012 m

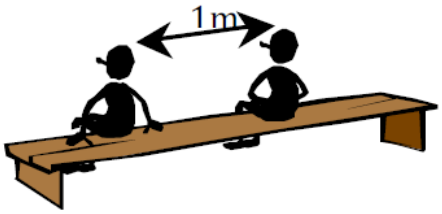
B 6560 m

C 3200 m

D 160 m

E 102 m (1)

2. Calculate the size of the gravitational pull of a sphere of mass 10 kg on a mass 2.0 kg when their centres are 200 mm apart. What is the force of the 2.0 kg mass on the 10 kg mass? (3)



3. Suppose that two objects attract each other with a gravitational force of 16 units. For each question explain your answer.

(a) If the distance between the two objects is doubled, what is the new force of attraction between the two objects?

(b) If the distance between the two objects is reduced in half, then what is the new force of attraction between the two objects?

(c) If the mass of both objects was doubled, and if the distance between the objects remained the same, then what would be the new force of attraction between the two objects?

(d) If the mass of both objects was tripled, and if the distance between the objects was doubled, then what would be the new force of attraction between the two objects? (8)

Total marks 12

Sheet 1.4c Our Dynamic Universe: Gravitation

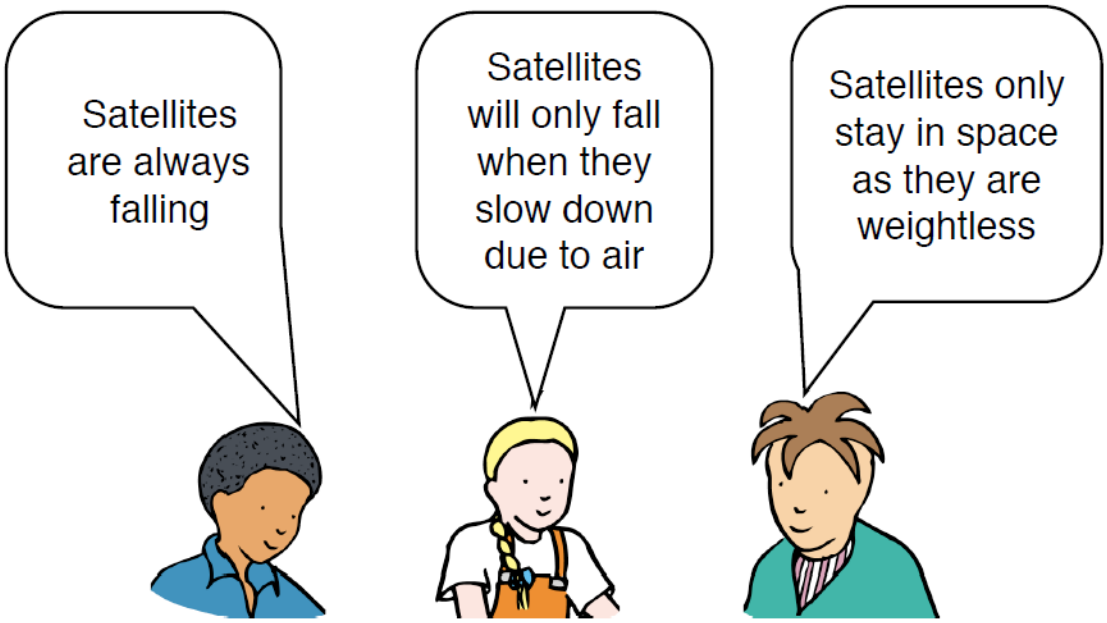
1. A research satellite, mass 100 kg, is in a circular orbit around the Earth. It is approximately 1.0 x 10^6 km from the Earth's centre (the Earth's mass is 5.97×10^{24} kg.)

(a) State Newton's Universal Law of Gravitation.

(b) Calculate the force of attraction of the Earth on the satellite.

(c) State the force of attraction of the satellite on the Earth. (5)

2. Use your knowledge of physics to help this group of pupils again.



(3)

3. Calculate the gravitational force between two cars parked 0·50 m apart. The mass of each car is 1000 kg.

(3)

4. In a hydrogen atom an electron orbits a proton with a radius of 5·30 × 10^{-11}m. The mass of an electron is 9·11 × 10^{-31} kg and the mass of a proton is 1·67 × 10^{-27} kg.

Calculate the gravitational force of attraction between the proton and the electron in a hydrogen atom.

(3)

Total 14 marks

Sheet 1.5 Our Dynamic Universe: Special Relativity

1. A spaceship on a launch pad is measured to have a length L. This spaceship has a speed of 2.5 x10^8 ms^{-1} as it passes a planet. Which row in the table describes the length of the spaceship as measured by the pilot in the spaceship and an observer on the planet.

Answer	Length measured by pilot on spaceship	Length measured by observer on the planet
A	L	less than L
B	L	greater than L
C	L	L
D	less than L	L
E	greater than L	L

(1)

2. A spaceship passes you at a speed of 0.80c. You measure its length to be 90.0 m. How long would it be at rest.

(3)

3. A spaceship travels to the Andromeda galaxy at 0.999999c. Its distance from Earth is 2.0 x10^6 light-years.

(a) How long does the trip take from a stationary observer's frame? (3)

(b) How long does it take the from the astronaut's frame? (3)

4. Spock is traveling at 0.2c on a shuttle with respect to the Enterprise. If he turns a torch on and sees the photons travel at light speed relative to himself, how fast are they moving relative to Scotty on board the Enterprise? Justify your answer.

(2)

Total 12 marks

Sheet 1.6a Our Dynamic Universe: The expanding Universe

1. The siren on an police car is emitting sound with a constant frequency of 800 Hz. The police car is traveling at a constant speed of 30 ms^{-1} as it approaches and passes a stationary observer. The speed of sound in air is 340 ms^{-1}.

Which row in the table shows the frequency of the sound heard by the observer as the police car approaches and as it moves away from the observer?

Answer	Frequency as police car approaches / Hz	Frequency as police car moves away / Hz
A	800	800
B	877	735
C	735	800
D	877	800
E	735	877

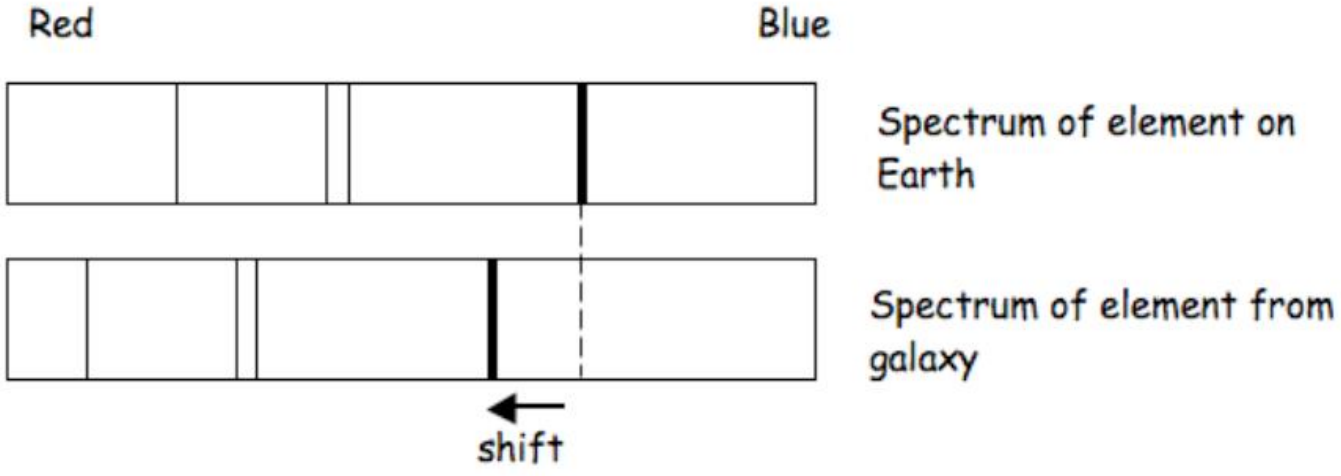
(1)

2. An ambulance travels towards an observer at 34 ms^{-1}. It's siren emits at 1500Hz in the ambulance's frame. What frequency does the observer hear? (3)

3. A girl tries out an experiment to illustrate the Doppler Effect by spinning a battery-operated siren around her head. The siren emits sound waves with a frequency of 1200 Hz. Describe and explain what would be heard by a stationary observer standing a few metres away.

(4)

4. Light from a distant galaxy is found to contain the spectral lines of hydrogen. The light causing one of these lines has a measured wavelength of 486 nm. When the same line is observed from a hydrogen source on Earth it has a wavelength of 434 nm.



(a) Calculate the Doppler shift, z, for this galaxy.

(b) Calculate the speed at which the galaxy is moving relative to the Earth.

(c) In which direction, towards or away from the Earth, is the galaxy moving? (7)

Total 15 marks

Sheet 1.6b Our Dynamic Universe: The expanding Universe

1. By observing the spectrum of light received from galaxy M101, astronomers have determined that the galaxy is moving away from us with a velocity of $5{\cdot}5 \times 10^5$ ms^{-1}.

(a) Calculate the distance of the galaxy from us.

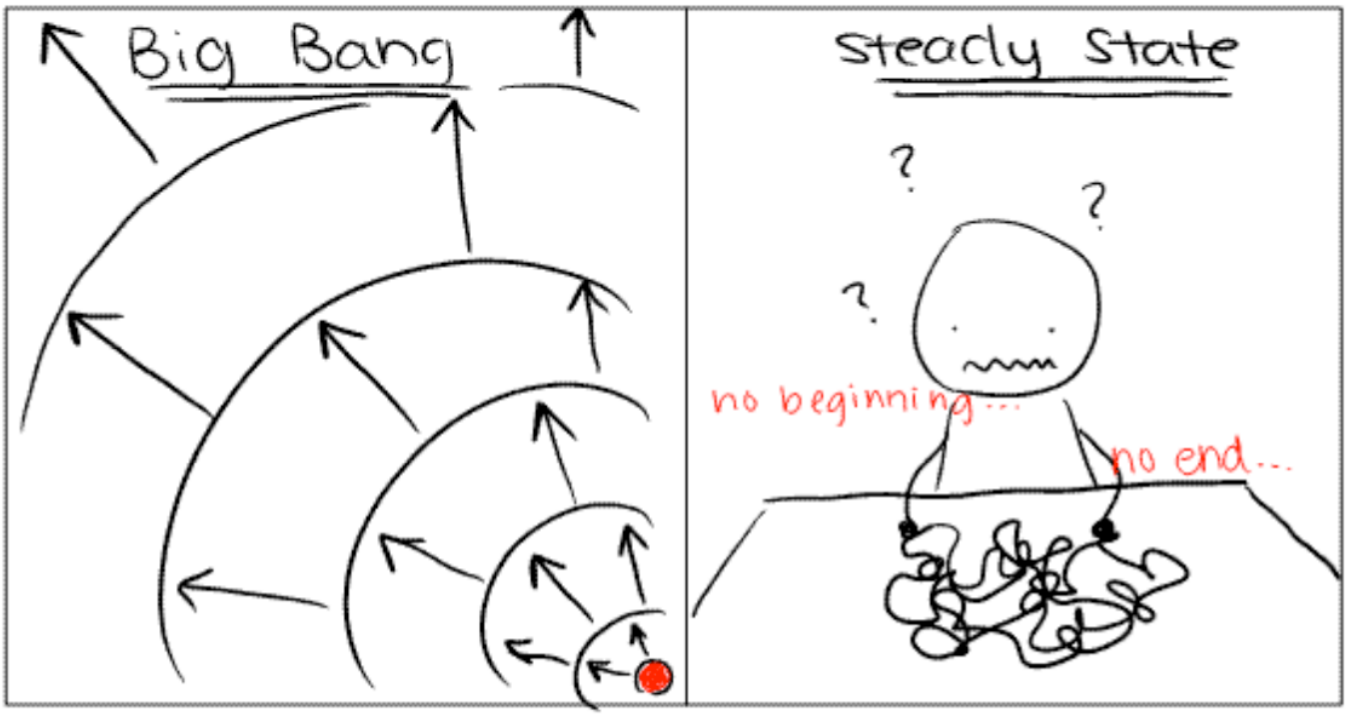
(b) Describe how the temperature of the cosmic microwave background is measured.

(5)

2. In fewer than 300 words, explain how Scientists have used redshift data from telescopes to give an accurate value for the age of the Universe

(3)

3. What is the difference between the Big Bang theory and the Steady State theory.



http://scienceclass.ning.com/profiles/blogs/1677792:BlogPost:1586

(2)

4. What is the evidence that supports the expanding Universe?

(2)

Total 12 marks

Sheet 2.1 Particles and Waves: The Standard Model

1. Which of these statements is/are correct?

(i) Hadrons are made up of quarks
(ii) The strong force holds quarks together
(iii) A proton is an example of a hadron

A (i) only
B (i) and (ii) only
C (i) and (iii) only
D (iii) only
E (i), (ii) and (iii) (1)

2. Physics attempt to describe the universe in terms of 4 fundamental forces
(a) What are the four fundamental forces?
(b) Briefly describe where the 'weak' and 'strong' forces act.
(c) Why is the gravitational force not included in the Standard Model?

(7)

3. Re-write the following quantities using the most appropriate prefix.
(a) 0.000006 m
(b) 1500000000 Hz
(c) 3200 W
(d) 0.008 g
(e) 2.7×10^{6} J
(f) 7.42×10^{-7} J (6)

4. According to modern particle theory, protons, and neutrons are composed of combinations of up and down quarks. Up quarks have a charge of +2/3e while down quarks have a charge of -1/3e.
(a) (i) Name the force which holds the quarks together in protons and neutrons.

(1)

(ii) State the combination of up and down quarks which make up:
(A) a proton
(B) a neutron

(2)

(b) A neutron can decay into a proton, electron and antineutrino. Name the force associated with this decay.

(1)

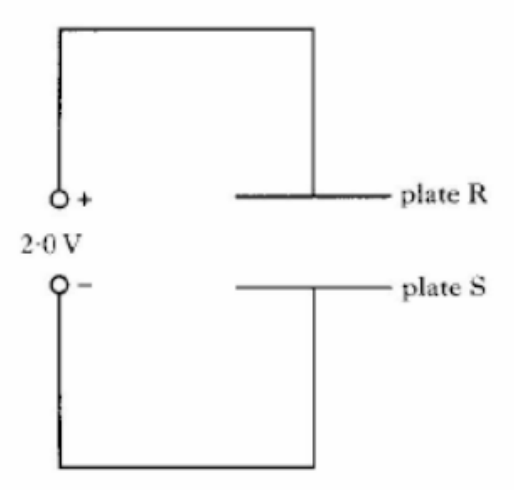
(c) The released electron has a kinetic energy of 0.15 MeV , what is its velocity?
(1 electron volt = $1.60217646 \times 10^{-19}$ joules) (4)

5. Describe the latest press release from the Large Hadron Collider at CERN?
(see http://press.web.cern.ch/press/ or search the news) (2)

Total 26 marks

Sheet 2.2a Particles and Waves: Forces on a charged particle

1. Two parallel plates, R and S, are connected to a 2.0 V d.c. supply as shown:

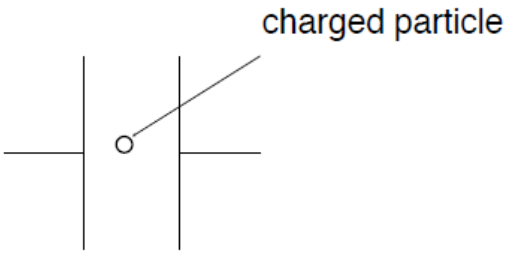


An electron moves from plate R to plate S. The gain in potential energy of the electron is

A. 8.0×10^{-20} J
B. 1.6×10^{-19} J
C. 3.2×10^{-19} J
D. 6.4×10^{-19} J
E. 1.3×10^{-19} J (1)

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

3. Look at the following diagram:



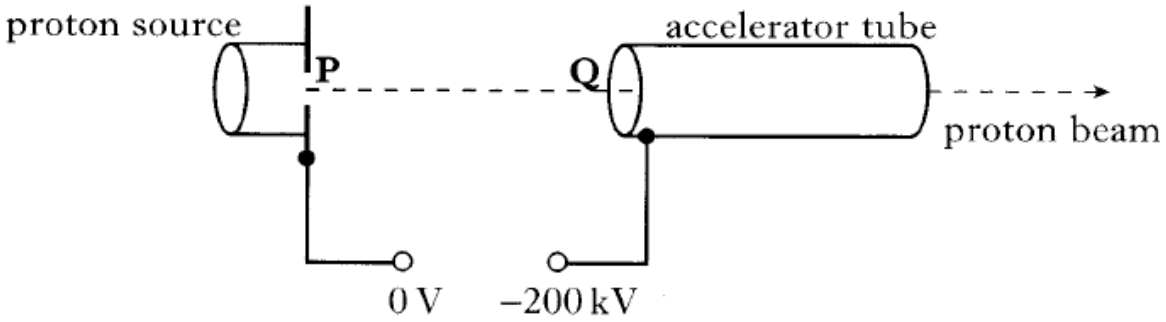
(a) What is the definition of the potential difference between the two plates? (1)
(b) The plates have potentials of 100V and 300V respectively. What is the potential difference between the two plates? (1)
(c) Calculate the work done energy in moving the charged particle (an electron) across the gap between the plates. (6)

4. Calculate the potential difference required to generate an electric field which can accelerate an electron to 6% of the speed of light in a vacuum. (6)

Total 16 marks

Sheet 2.2b Particles and Waves: Forces on a charged particle

1. The diagram below shows the basic features of a linear proton accelerator. It is enclosed in an evacuated container.



Protons released from the proton source start at rest at point P. A potential difference of 200 kV is maintained between P and Q.

(a) What is meant by the term "a potential difference of 200 kV"? (1)

(b) Explain what happens to the protons released at point P (2)

(c) Calculate:

(i) the work done on a proton as it accelerates from P to Q (3)

(ii) the speed of a proton as it reaches Q (4)

(d) The distance between points P and Q is now halved.
What effect, if any, does this have on the speed of the proton as it reaches Q?
Justify your answer. (2)

2. A first year pupil asks you to explain why the CERN particle accelerator is a circle and how it works. Write out an explanation (include the terms: electric field, magnetic field and charged particle in your answer)
(3)

Total 15 marks

Sheet 2.3a Particles and Waves: Nuclear Reactions

1. Which of these statements best describes nuclear fission?

(a) A nucleus of large mass number splits into two nuclei, releasing several neutrons;
(b) A nucleus of large mass number splits into two nuclei, releasing several electrons;
(c) A nucleus of large mass number splits into two nuclei, releasing several protons;
(d) Two nuclei combine to form one nucleus, releasing several electrons;
(e) Two nuclei combine to form one nucleus, releasing several neutrons.

(1)

2. 1n 1908, Rutherford carried out his famous alpha-particle scattering experiment. The particles were fired at a target, and a detector was used to determine the amount of alpha particles scattered in any particular direction around the target.

a. What material did Rutherford use as a target? (1)
b. What does an alpha particle consist of? (1)
c. Describe the results of the experiment. (3)
d. State the three main conclusions drawn about the atom from the results of the experiment. (3)

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

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

(a) What type of reaction is this? (2)
(b) Calculate the missing numbers X and Y (2)
(c) Using the information in the table below, calculate the energy released in this reaction (5)

Nucleus or Particle	Mass (u)
Pu	239.0512
Te	137.0000
Mo	99.9066
n	1.0087

(Note u is the mass of a proton: 1.66 x 10^{-27} kg)

Total 15 marks

Sheet 2.3b Particles and Waves: Nuclear Reactions

1. (a) Two possible nuclear reactions involving uranium are represented by the statements shown below:

Statement A: $^{235}_{92}U + ^{1}_{0}n \rightarrow ^{134}_{52}Te + ^{98}_{40}Zr + 4^{1}_{0}n$

Statement B: $^{235}_{92}U + ^{1}_{0}n \rightarrow ^{144}_{56}Ba + ^{90}_{36}Kr + 2^{1}_{0}n$

The masses of the nuclei and particles involved in the reactions are as follows:

Nucleus or Particle	Mass (u)
U	3.901 x 10^{-25} kg
Te	2.221 x 10^{-25} kg
Zr	1.626 x 10^{-25} kg
Ba	2.388 x 10^{-25} kg
Kr	1.492 x 10^{-25} kg
n	0.17 x 10^{-25} kg

(i) What type of nuclear reaction is described by both statements A and B? (1)

(ii) Show by calculation how much mass is "lost" in each of the reactions A and B (6)

(iii) Explain which of the reactions A or B releases the greater amount of energy (2)

(b) A third possible nuclear reaction is represented by the following statement:

$$^{235}_{92}U + ^{1}_{0}n \rightarrow ^{98}_{42}Mo + ^{136}_{y}Xe + 2^{1}_{0}n + 4^{0}_{-1}e$$

(i) What is the atomic number for Uranium? (1)

(ii) What is the mass number for Uranium? (1)

(iii) Determine the value of y (1)

Total 12 marks

Sheet 2.4a Particles and Waves: Wave Particle Duality

1. (a) When light of frequency f is shone on to a certain metal, photoelectrons are ejected with a maximum velocity v and kinetic energy E_k. Two lights with the same frequency are now shone on the same metal. Which of the following statements is/are true?

I Twice as many electrons are ejected per second.

II The speed of the fastest electron is 2v.

III The kinetic energy of the fastest electron is now $2E_k$

A. I only
B. I and II only
C. I and III only
D. III only
E. I, II and III (1)

2. The work function for sodium metal is 2.9×10^{-19} J . Light of wavelength 5.4×10^{-7} m strikes the surface of this metal. What is the kinetic energy of the electrons emitted from the surface?

[Data:- Planck's constant = 6.63×10^{-34} Js] (3)

3. 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?

(3)

(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.

(4)

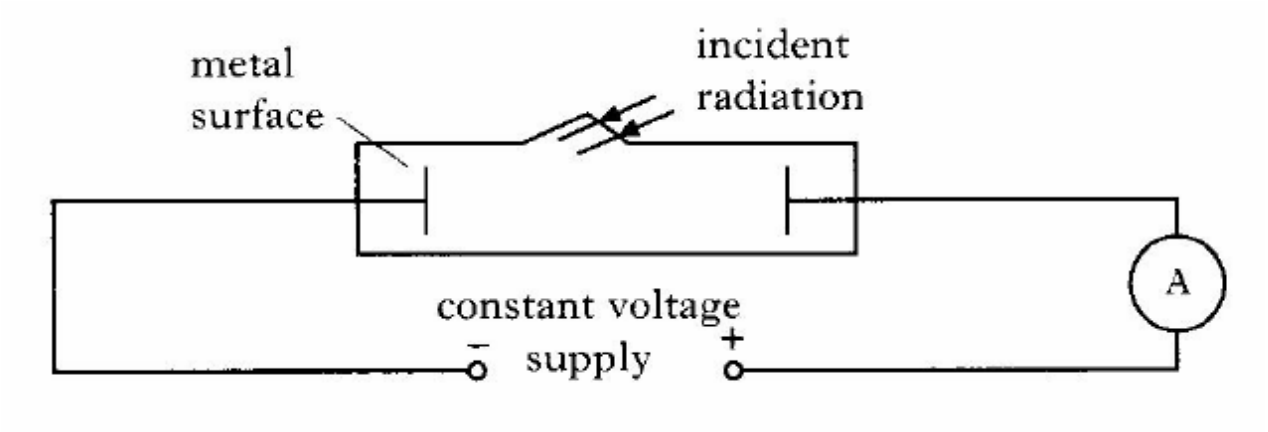
(c) Calculate the kinetic energy that the ejected electrons will have when the metal is illuminated with this light.

(3)

Total 14 marks

Sheet 2.4b Particles and Waves: Wave Particle Duality

1. (a) The apparatus shown below is used to investigate photoelectric emission from a metal surface when electromagnetic radiation is shone on the surface. The intensity and frequency of the incident radiation can be varied as required.



(i) Explain what is meant by photoelectric emission from a metal. (2)

(ii) What is the name given to the minimum frequency of the radiation that produces a current in the circuit?

(1)

(iii) A particular source of radiation produces a current in the circuit. Explain why the current in the circuit increases as the intensity of the incident radiation increases.

(2)

(b) A semiconductor chip is used to store information. The information can only be erased by exposing the chip to ultraviolet radiation for a period of time.

The following data is provided.

Frequency of ultraviolet radiation used = 9.0×10^{14} Hz
Minimum intensity of ultraviolet radiation required at the chip = 25 Wm^{-2}
Area of the chip exposed to radiation = 1.8×10^{-9} m^2
Time taken to erase the information = 15 minutes
Energy of radiation needed to erase the information = 40.5×10^{-6} J

(i) Calculate the energy of a photon of the ultraviolet radiation used.

(3)

(ii) Calculate the number of photons of the ultraviolet radiation required to erase the information.

(3)

(ii) Sunlight of intensity 25 Wm^{-2}, at the chip, can also be used to erase the information. State whether the time taken to erase the information is greater than, equal to or less that 15 minutes. You must justify your answer.

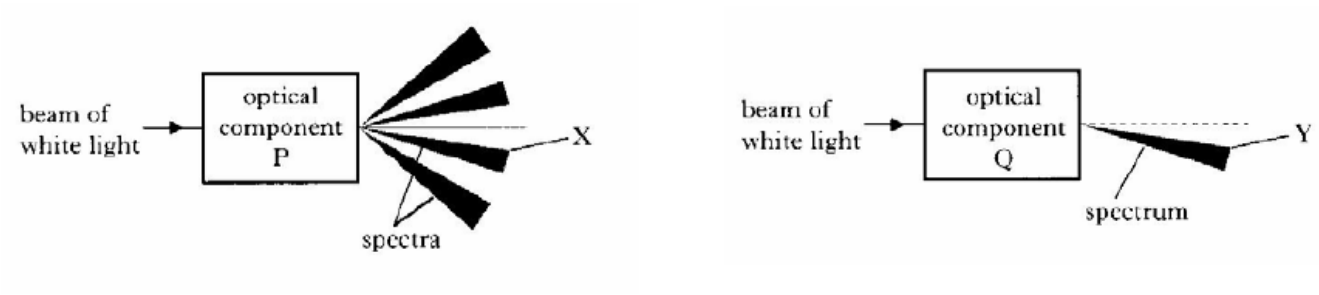
(3)

2. A teacher wrote "In the great debate between particles and waves, one of the important factors affecting photoelectric emission from a metal is the threshold frequency for the metal". Use your knowledge of physics to comment on this statement (3)

Total 17 marks

Sheet 2.5a Particles and Waves: Interference and Diffraction

1. A beam of white light is passed through two optical components P and Q. Component P produces a number of spectra and component Q produces a spectrum as shown.

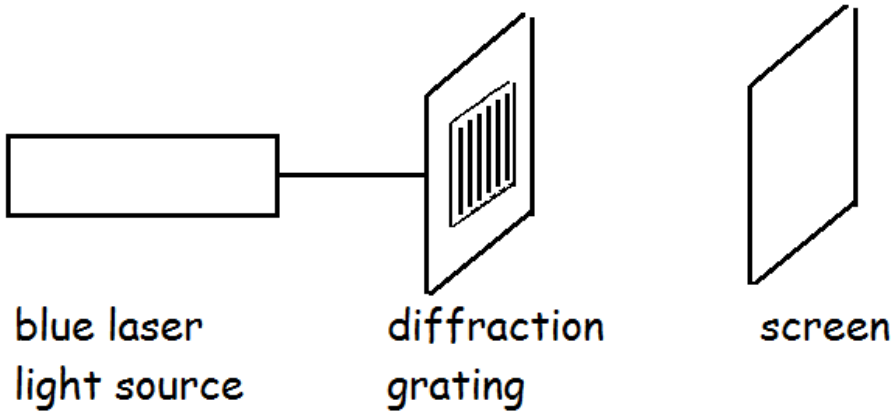


Which row in the table identifies the optical components and the colour of the light seen at position X and position Y?

Optical component P	Colour seen at X	Optical component Q	Colour seen at Y
Grating	Red	Triangular prism	Red
Grating	Red	Triangular prism	Violet
Grating	Violet	Triangular prism	Red
Triangular prism	Red	Grating	Violet
Triangular prism	Violet	Grating	Red

(1)

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



(a) Describe what is seen on the screen.

(2)

(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.

(3)

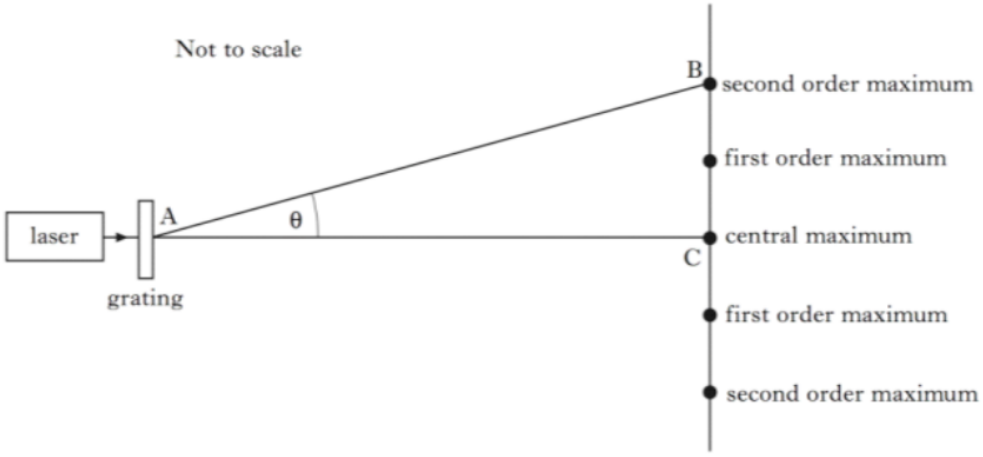
(c) If the wavelength of the red light used is 700 nm, and the diffraction grating has 100 lines per millimetre, calculate the angle between the first order maximum and the second order maximum.

(6)

Total 12 marks

Sheet 2.5b Particles and Waves: Interference and Diffraction

1. An experiment to determine the wavelength of light from a laser is shown.



A **second** order maximum is observed at point B.

(a) Explain in terms of waves how a maximum is formed. (1)

(b) Distance AB is measured six times.

The results are shown.

1.11 m 1.08 m 1.10 m 1.13 m 1.11 m 1.07 m

(i) Calculate:

(A) the mean value for distance AB; (1)

(B) the approximate random uncertainty in this value. (3)

(ii) Distance BC is measured as (270 ± 10) mm. Show whether AB or BC has the larger percentage uncertainty.

(3)

(iii)The spacing between the lines on the grating is 4.00×10^{6} m.

Calculate the wavelength of the light from the laser. Express your answer in the form:

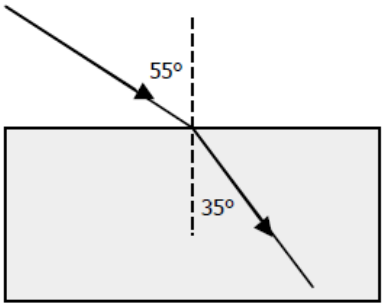
wavelength ± **absolute** uncertainty (5)

5. A holographic image is made by splitting a laser beam. Research holographs, how they are made and how interference helps. Include your references. (3)

Total 16 marks

Sheet 2.6a Particles and Waves: Refraction

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:



(a) Calculate the refractive index of the block of plastic. (3)

(b) What is the wavelength of the red light in the block of plastic? (3)

(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 her boyfriend. Just as she is presenting the Diamond engagement ring to him, she notices the sparkling is caused by total internal reflection. She is so taken by this observation, she rushes off to find out the refractive index of diamond so that she can calculate the critical angle for the diamond. Her boyfriend immediately dumped her.

(a) If the refractive index of diamond is 2.42 calculate the critical angle. (3)

(b) Describe what is meant by critical angle (2)

3. A beam of monochromatic light of frequency 4.85×10^{14} Hz passes from air into liquid paraffin. In liquid paraffin the light has a speed of 2.10×10^{8} ms^{-1}.

(a) Calculate the refractive index of the liquid paraffin. (3)

(b) What is the frequency of the light when it is in the liquid paraffin? (1)

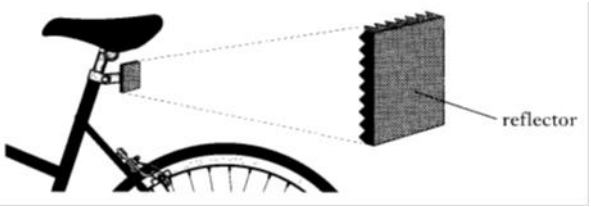
Total 16 marks

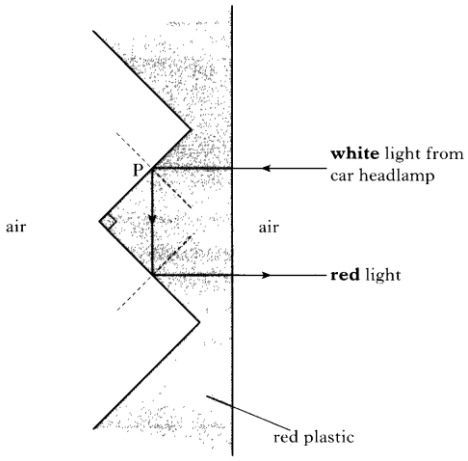
Sheet 2.6b Particles and Waves: Refraction

1. (a) The critical angle for light in a type of red plastic is 41°. Show that the refractive index of this red plastic is 1.52.

(3)

(b) This red plastic is used to make the rear reflector on a bicycle. The diagrams below show the rear reflector on the bicycle and an enlarged view of the reflector.





Light from a car headlamp is reflected back to the car as shown in the diagram above.

(i) Explain why total internal reflection takes place at P.

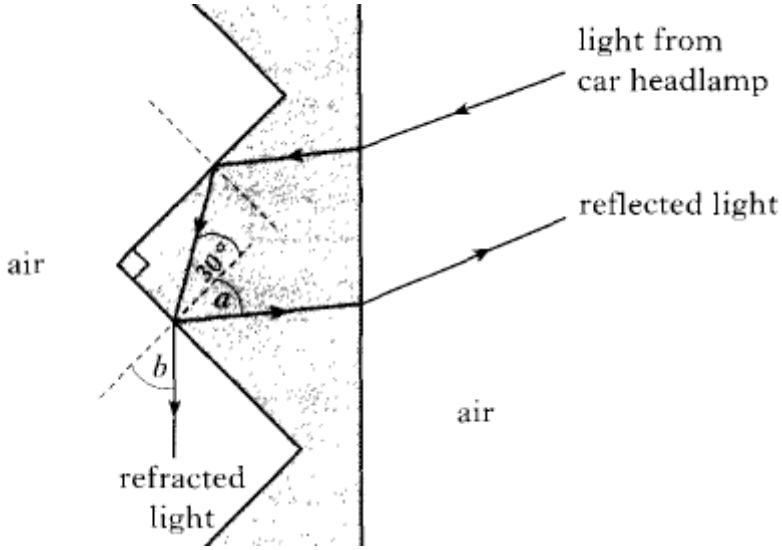
(1)

(ii) Why is the intensity of the reflected light less than the intensity of the light incident on the reflector?

(1)

(c) A ray of light from another car strikes the reflector from a different direction as shown below. The refractive index of the red plastic is 1.52. Calculate the values of angles a and b.

(4)

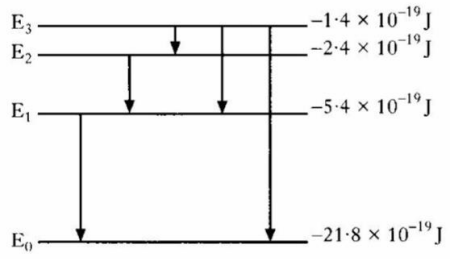


2. Research: What is a double rainbow and how are they formed? Give your references. (3)

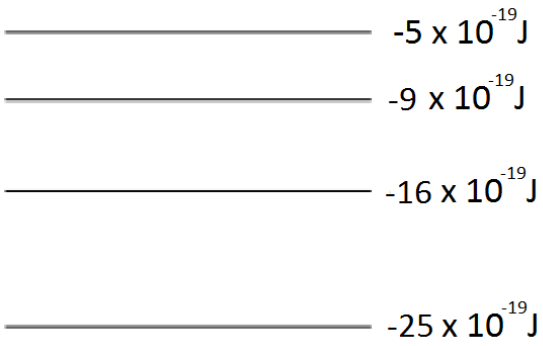
Total 12 marks

Sheet 2.7 Particles and Waves: Spectra

1. The diagram below represents some electron transitions between the energy levels in an atom. The radiation emitted with the shortest wavelength is produced by an electron making transition between which two energy levels? (1)

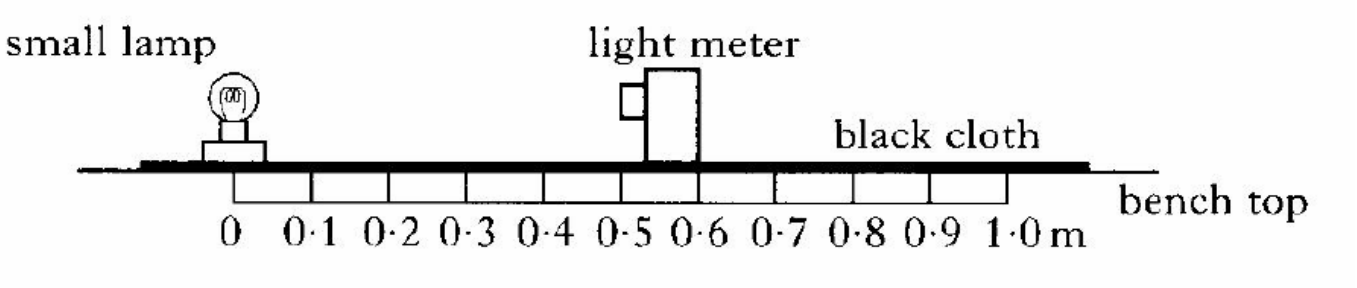


2. The following diagram represents the energy levels of a particular metal's atoms.



(a) How many possible transitions are there for this atom? (1)
(b) Calculate the maximum frequency of light absorbed by this atom. (3)
(c) Which part of the spectrum would this absorption line be found in? Explain your answer. (4)
(visible light is between 400 - 700 nm)

3. A student carries out an experiment to investigate how irradiance on a surface varies with distance from a small lamp. Irradiance is measure with light meter. The distance between the small lamp and the light meter is measured with a meter stick. The apparatus is set up as shown in a darkened laboratory.



The following results are obtained.

Distance from source / m	0.20	0.30	0.40	0.50
Irradiance / Wm^{-2}	675	302	170	108

(a) What is meant by the term irradiance? (1)
(b) Use a graph to find the relationship between irradiance I and distance d from the source. (4)
(c) What is the purpose of the black cloth on top of the bench? (1)
(d) The small lamp is replaced by a laser. Light from the laser is shone on the the light meter. A reading is taken from the light meter when the distance between it and the laser is 0.50m. The distance is now increased to 1.00m.
State how the new reading on the light meter compares with the one taken at 0.50m.
Justify your answer. (2)

4. How do emission lines help with star identification? (3)

Total Marks 20