

Open Ended Questions

OEQ 1

The car manufacturer SATSUMA notices that in one of their new models although the battery voltage states 12V as soon as the engine is started the lights go dim; indicating that they are operating at less than 12V.

Using your knowledge of physics explain how this might happen. 3 marks

OEQ 2

The text in the paragraph below has been transcribed from a football commentator's dialogue describing a players' moves on the field.

"Giggs ran down the field, jumped into the air and hung there before heading the ball over the net"

Using Physics principles, comment on the paragraph. 3 marks

OEQ 3

Estimate the heat energy produced by a bicycle's brakes as a moving cyclist decelerates to rest. Clearly show your working for your calculations and any estimates you have made.

3 marks

OEQ 4

Two pupils are discussing how rockets move :

Peter states to Jessica ‘ *the rocket gases push on the ground and this causes the rocket to travel upwards.*’

Use your knowledge of Physics to explain why this is not true. 3 marks

OEQ 5

When cars brake to a halt, the kinetic energy of the vehicle is turned into heat and sound energy. As part of the drive to make cars more efficient some manufacturers are experimenting with flywheels that store this kinetic energy as rotational energy (the flywheel rotates). Estimate the quantity of energy that could be stored in such a flywheel. Clearly show any calculations and assumptions you make.

3 marks

OEQ 6

Describe how you could estimate the height of a cliff using just a rock and a stopwatch. Include details of any data you would need and calculations you may make. Include a discussion of any likely sources of error. 3 marks

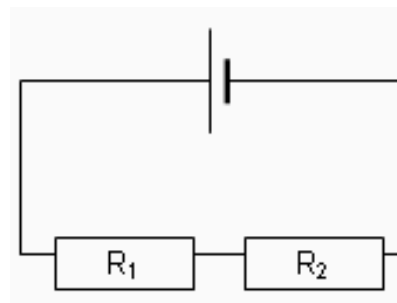
OEQ 7

You have a choice of two identical mallets with which to hammer in a large tent peg. Each mallet has the same mass and has the same length handle. One has a head made of rubber, the other a head made of steel. Using your knowledge of physics, justify which mallet you would choose to use. (3)

OEQ 8

If it were possible to travel at the speed of light, you could be in all places at all times." Using your understanding of physics, discuss this statement. (3)

OEQ 9



In discussing this circuit a pupil makes the following statement:

As the charges move round the circuit, they do so from negative to positive. Some of the charges are consumed by R_1 and the remaining charges by R_2 . This is why voltages in a series circuit add up to the supply voltage.

Use your knowledge of Physics to comment on this statement.

Written Questions – Our Dynamic Universe

ODU 1

It is predicted that neutrons travel out from the sun towards the Earth with a speed of $0.3c$. Scientists on Earth measure the distance from the Earth to the Sun and find it to be 150×10^6 km.

- a) Show that the speed of the neutrons is 9×10^4 kms⁻¹ **2**
- b) Calculate the distance from the Sun to the Earth that would be observed by one of these neutrons. **2**

When at rest the mean lifetime of a neutron is 15 minutes before it naturally decays.

- c) Calculate the mean lifetime for neutrons that would be measured by an observer when the neutrons are moving at $0.3c$ relative to the observer. **2**

Light travels from the Sun to the Earth overtaking neutrons on the way.

- d) What is the relative speed between the light and the neutrons as the light passes the neutrons? **1**

(7)

ODU 3

A fire engine travelling at 20ms^{-1} emits sound waves with a frequency of 1000 Hz from its siren.

(a) Calculate the frequency heard by a stationary observer as the police car moved **towards** her.

2

(b) Explain why the sound heard by the observer does not have a frequency of 1000 Hz. You may wish to include a diagram to support your answer.

1

Marking Scheme

(a) $f_{\text{obs}} = f_s (v/(v-v_s))$

$$f_{\text{obs}} = 1000 \times (340/(340-20)) = \mathbf{1060 \text{ Hz}}$$

(b) The frequency is greater than 1000Hz as the wavelength of the emitted wave decreases as the source moves towards the observer.

ODU 4

The spectrum of light from most stars contains lines corresponding to helium gas.

Figure 15(a) shows the helium spectrum from the Sun.

Figure 15(b) shows the helium spectrum from a distant star.

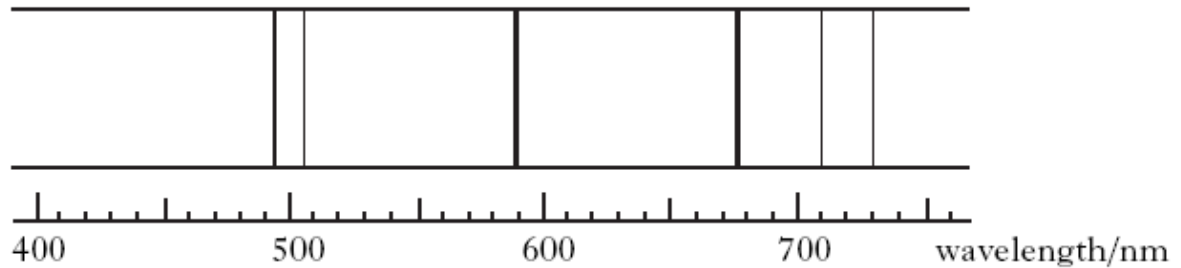


Figure 15(a)

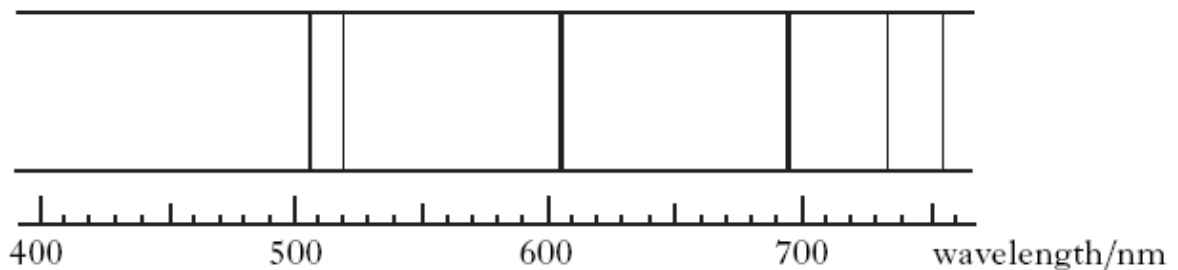


Figure 15(b)

By comparing these spectra, what conclusion can be made about the distant star?
Justify your answer.

2

Marking Scheme

moving away

wavelength increased

OR frequency decreased

(1)

(1)

Second mark only
available if "moving
away" is present.

2

ODU 5

A plane can accelerate at a maximum of 4.0ms^{-2} and needs to reach a take-off speed of 80ms^{-1} . What is the *minimum* length of runway it needs to become airborne?

(2)

Marking scheme

Use of $v^2 = u^2 + 2as$ ($\frac{1}{2}$)

$$s = (v^2 - u^2)/2a \qquad s = (80^2 - 0^2)/(2 \times 4) \quad (\frac{1}{2})$$

$$s = 400\text{m} \quad (1)$$

ODU 6

Sketch a velocity time graph for a free fall skydiver for the initial 30 seconds of her fall *before* she puts her parachute up. You can assume that she reaches terminal velocity after 20 seconds.

(3)

Marking scheme

Graph drawn with appropriate axes and labels (1)

Initial section showing steady acceleration ($\frac{1}{2}$), which begins to reduce ($\frac{1}{2}$) until it becomes a horizontal line ($\frac{1}{2}$) at 20s ($\frac{1}{2}$)

ODU 7

A wooden block of mass 10kg slides down a slope of 12° at a constant speed of 2ms^{-1} .

- (a) What is the weight of the block? (2)
- (b) What is the component of the weight acting down the slope? (2)
- (c) What frictional force is acting on the block and in which direction? (1)
- (d) How much potential energy is lost by the block each second? (2)

(e) Marking scheme

(a) $W = mg$ ($\frac{1}{2}$)

$$= 10 \times 9.8 \quad (\frac{1}{2})$$

$$= 98\text{N} \quad (1)$$

(b) Use of $F = mgsin\theta$ or similar ($\frac{1}{2}$)

$$F = 10 \times 9.8 \times \sin 12 \quad (\frac{1}{2})$$

$$F = 20.38\text{N}, 20\text{N} \quad (1)$$

(c) 20N upslope (1)

(d) Either: $W = Fs$ ($\frac{1}{2}$), $= 20.38\text{N} \times 2\text{m/s}$ ($\frac{1}{2}$) $= 41\text{J}$ (1)

Or: E_p lost per second $= mgh$ ($\frac{1}{2}$) $= 10 \times 9.8 \times (2 \times \sin 12)$ ($\frac{1}{2}$) $= 41\text{J}$ (1)

ODU 8

A 500g ice hockey puck moves across a frictionless surface at 8m/s, and collides with an identical puck moving at 4m/s in the opposite direction. The first puck then stops completely. After the collision:

- (a) Using the principal of conservation of momentum, show by calculation whether the collision is elastic or inelastic. (9)

The collision takes place over a time of 50ms.

- (b) What is the average force acting on the first puck during this collision? (2)
(c) Explain any differences you would expect to see if the collision was repeated with pucks of the same masses, but made of softer materials. (2)

Marking scheme

- (a) Using conservation of momentum ($\frac{1}{2}$)

$$\text{Before, } p = mv \left(\frac{1}{2}\right) = 0.5 \times 8 - 0.5 \times 4 \text{ (1)} = 2 \text{ kgm/s}$$

So, since momentum after is also 2kgm/s and the first puck stops, the second puck moves at:

$$v = p/m = 2/0.5 = 4 \text{ m/s (2)}$$

$$E_k \text{ before} = \frac{1}{2}mv^2 \text{ for each puck } \left(\frac{1}{2}\right)$$

$$= \frac{1}{2} \times 0.5 \times (8 \times 8) + \frac{1}{2} \times 0.5 \times (4 \times 4) \left(\frac{1}{2}\right)$$

$$= 20 \text{ J (1)}$$

$$E_k \text{ after} = \frac{1}{2}mv^2 \left(\frac{1}{2}\right)$$

$$= \frac{1}{2} \times 0.5 \times (4 \times 4) \left(\frac{1}{2}\right)$$

$$= 4 \text{ J (1)}$$

So **not** elastic. (1)

$$\text{(b) } F = (mv - mu)/t \left(\frac{1}{2}\right)$$

$$= (0 - (0.5 \times 8))/0.050 \left(\frac{1}{2}\right)$$

$$= (-) 80 \text{ N (1)}$$

- (c) longer time of impact (1) so smaller average forces (1)

ODU 9

A 100m long spacecraft travels past an observer (who is in an inertial frame of reference), at 75% of the speed of light.

- (a) Explain what is meant by an inertial frame of reference. (1)
- (b) Calculate the length of the spacecraft as seen by the observer. (2)
- (c) How long does the spacecraft appear to its pilot? (1)

Marking scheme

(a) A frame of reference which is at rest or at constant velocity; no acceleration. (1)

(b) $l' = l \times \text{sqrt}(1 - v^2/c^2)$ (½)

$$= 100\text{m} \times \text{sqrt}(1 - 0.75^2) \text{ (½)}$$

$$= 66\text{m} \text{ (1)}$$

(c) 100m (1)

ODU 10

A Russian Soyuz rocket has launched from French Guiana - only the second such vehicle to fly out of the territory's new Sinnamary spaceport.

The Soyuz put six satellites in orbit, including France's new Pleiades-1 high-resolution imaging spacecraft.

This satellite is designed to produce pictures that resolve features on the ground as small as 50cm across.

The capability will put it on a par with the leading US commercial systems operated by GeoEye and DigitalGlobe.

Lift-off occurred on schedule at 23:03 local time, Friday 16 December 2011 with Pleiades-1 being dropped off in its 700km-high polar orbit some 55 minutes later.

The 970kg satellite is the result of a near-decade-long programme in the French space agency (Cnes) to develop one of the most powerful Earth observation systems in the world.

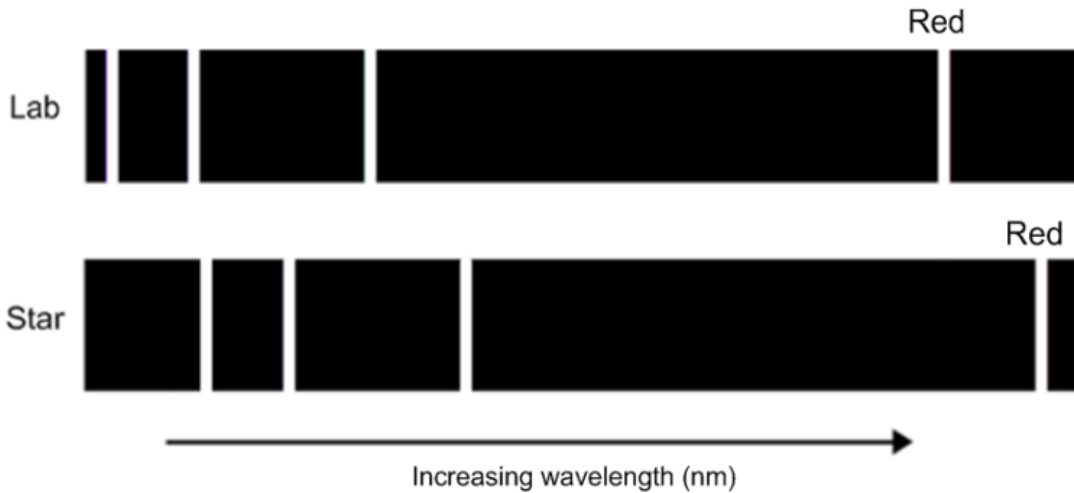
- (a) State Newton's Law of Gravitation
- (b) Calculate the size of the gravitational force on the satellite in its orbit.
- (c) Calculate the size of the gravitational field strength in this orbit

Marking scheme

- a) Correct formula or similar in words
- a) Correct use of formula should give $9 \times 10^3 \text{N}$ with massive rounding!
- a) Correct use of formulae should give 9.28 N/kg or thereabouts

ODU 11

Emission spectra of the element hydrogen are shown below, one from a source in a laboratory on Earth and another from a distant star.



(a) Using your knowledge of physics, comment on the differences in these two spectra.

(3)

(b) The hydrogen source on the Earth, emits a red emission line of wavelength 656 nm. The red emission line from the star is measured to have a wavelength of 676 nm. Calculate the speed of the star relative to the Earth.

3

(c) Calculate the distance of the star from earth in light years. (Take Hubble's constant to be $H_0 = 2.4 \times 10^{-18} \text{ s}^{-1}$ and $1 \text{ lightyear} = 9.5 \times 10^{15} \text{ m}$)

(3)

Marking scheme

(a). Answer: (should mention some of the following points, use professional judgement)

- The apparent wavelength of the hydrogen spectra from the star has increased
- The apparent frequency of the hydrogen from the star is lower than the actual frequency on earth
- The frequency of the light from hydrogen has shifted towards the red end of the visible spectrum
- Light from the star is experiencing a Doppler Shift
- The star is moving away from the earth

ODU 11 Marking scheme (continued)

(b) Answer:

$$z = \frac{\lambda_{\text{obs}}}{\lambda_{\text{emitted}}} - 1$$

$$z = \frac{676 \times 10^{-9}}{656 \times 10^{-9}} - 1 = 0.03$$

$$z = \frac{v}{c}$$

$$v = 0.03c$$

$$v = \underline{9 \times 10^6 \text{ ms}^{-1}}$$

(c) Answer:

$$v = H_0 d$$

$$d = \frac{v}{H_0}$$

$$d = \frac{9 \times 10^6}{2.4 \times 10^{-18}}$$

$$d = 3.75 \times 10^{24} \text{ m}$$

1 lightyear = 9.5×10^{15} m, therefore

$$d = \frac{3.75 \times 10^{24}}{9.5 \times 10^{15}}$$

$$d = \underline{3.95 \times 10^8 \text{ lightyears}}$$

ODU 12

A starship 20 metres long is travelling at a constant speed of 0.95 c. The spacecraft travels at this speed for 2 days, as measured by a clock on the Earth.

- (a) Calculate how many days have passed, as measured by a clock in the starship. (2)
- (b) Calculate the distance travelled by the starship as measured by an observer on the starship in metres. (1)
- (c) Calculate the length of the starship as observed by a person on earth, as it travels at 0.95c. (2)

Markings scheme

Answer:

$$(a) t' = t \frac{1}{\text{SQRT}(1 - v^2/c^2)}$$

$$2 = \frac{t}{\text{SQRT}(1 - 0.95c^2/c^2)}$$

$$2 = \frac{t}{\text{SQRT}(1 - 0.9025)}$$

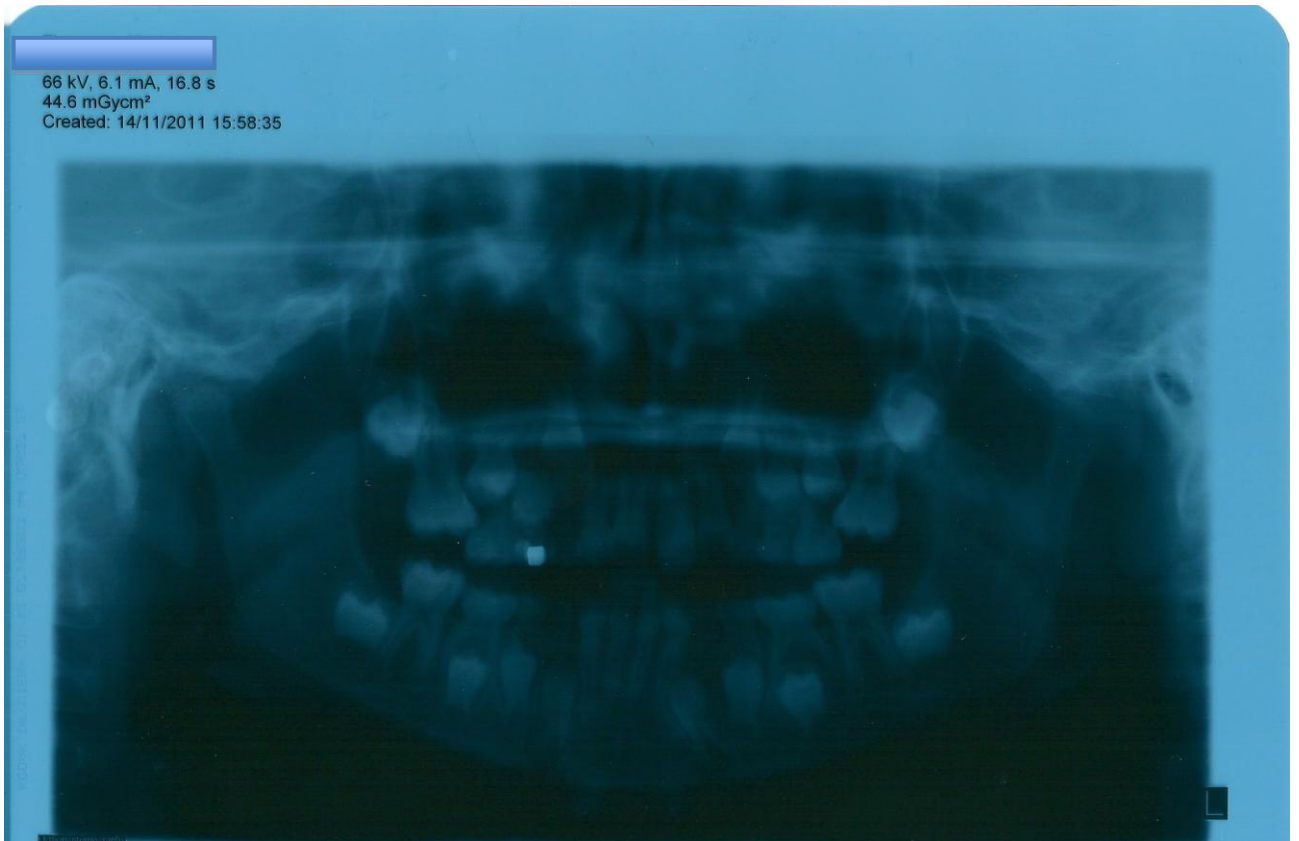
$$t' = \underline{0.62 \text{ days}}$$

$$(b) d = v t$$
$$d = (0.95 \times 3 \times 10^8) \times (0.62 \times 24 \times 60 \times 60)$$
$$d = \underline{1.53 \times 10^{13} \text{ m}}$$

$$(c) l' = l(\text{SQRT}(1 - v^2/c^2))$$
$$l' = 20(\text{SQRT}(1 - 0.9025))$$
$$l' = \underline{6.2 \text{ m}}$$

Written Questions - Particles and Waves

A girl receives a dental X ray.



From the information on the photograph calculate the following :

- b) The total electric charge required.
- c) The work done.
- d) The number of electrons released.
- e) Using your knowledge of physics comment on any similarities to a particle accelerator and any differences.

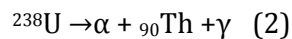
Marking Scheme

- b) $Q=It=6.1 \times 10^{-3} \times 16.8=0.1\text{C}$
- b) $W=QV=0.1 \times 66000=6764\text{J}$
- c) $\text{No of electrons} = 0.1 / 1.6 \times 10^{-19} = 5 \times 10^{17}$
- d) A high voltage is used to produce X rays in order to investigate matter. However there is no magnetic containment field.

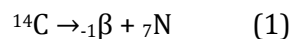
Give an example of a *lepton* and a *hadron*. Explain how the structure of a proton and a neutron can be made from up (+2/3) and down (-1/3) quarks. (2)

P&W 3

(a) Fill in the missing numbers for these decay events:



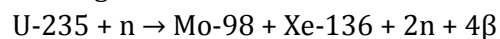
And (b):



(c) Where does the energy in a nuclear fission or fusion event come from? (1)

(d) Why is it not possible to fuse iron nuclei? (2)

(e) In the following fission reaction, calculate the energy released:



Masses: U = 234.993u, Xe = 135.878u, Mo = 97.883u, n = 1.009u and e = 0.0005u
where u is the unified atomic mass unit, $1.660 \times 10^{-27}\text{kg}$. (4)

Marking scheme

(a) Missing numbers – top row 4, 234, 0 (or missing); bottom row 92, 2, 0 (or missing). Max 2 marks; ½ mark deducted for each error.

(b) Missing numbers – top row 0,14; bottom row 6. Max 1 mark; ½ mark deducted for each error.

(c) The mass defect/deficit (½) is changed into energy according to $E = \Delta mc^2$ (½).
Or, some of the mass is changed into energy. (1)

(d) Not possible because an enormous amount of energy needs to be put in (1) to fuse iron into larger nuclei due to its high binding energy/low mass per nucleon (1).

(e) Total mass before = $234.993 + 1.009 \text{ u}$ (½)

Total mass after = $97.883 + 135.878 + 2(1.009) + 4(0.0005) \text{ u}$ (½)

Difference = $236.002 - 235.781 = 0.221\text{u} = 3.6686 \times 10^{-28}\text{kg}$ (1)

Energy released = mc^2 (½)

$$= 3.6686 \times 10^{-28} \times 9 \times 10^{16} \text{ (½)}$$

$$= 3.30 \times 10^{-11} \text{ J (1)}$$

P&W 4

- (a) Sketch the electric field lines around (i) two positive point charges placed a few cm apart and (ii) two oppositely charged parallel plates, also a few cm apart. (4)
- (b) An alpha particle is accelerated through a potential difference of 100V, in a vacuum. Calculate its velocity. If the experiment was repeated with an electron, how would the value of the kinetic energy and velocity of the electron compare with that of the alpha particle? (no need for a calculation) (3,3)
- (c) If an electron and an alpha particle were then passed at identical speeds between the poles of a magnet, sketch how their paths would differ. (2)

Marking scheme

(a) (i) and (ii) Shapes correct (1) mark each, including approx uniform field between plates; arrows to show correct direction (1) mark each.

(b) $QV = \frac{1}{2}mv^2$ (1)

$$2 \times (1.6 \times 10^{-19}) \times 100 = \frac{1}{2} (4 \times 1.66 \times 10^{-27}) \times v^2 \quad (1)$$

$$v = 6.9 \times 10^4 \text{ m/s} \quad (1)$$

For an electron, it has only half the charge, so would have only half the kinetic energy. (1) However, it would have much less mass (1), and so a much larger speed (1) – could say velocity is in the opposite direction (1). Max 3 marks.

(c) Alpha particle and electron follow curved paths (1), in opposite directions (1). Electron's path is much tighter curve (1) due to much smaller mass in spite of having only half the charge.

P&W 5

- (a) Give the meanings of (i) threshold frequency and (ii) work function (2)
- (b) UV light with a frequency of 3.5×10^{16} Hz is shone onto a metal surface with a work function of 1.8×10^{-17} J. (i) Calculate the maximum kinetic energy of emitted photoelectrons. (2) (ii) If the mass of an electron is 9.11×10^{-31} kg, find the electron's speed. (2)
- (c) If light with a frequency of 1.5×10^{16} Hz was shone onto the metal surface in (b) above, explain why electrons would not be released from the surface. (1)

Marking scheme

(a) (i) **Min** frequency which will cause photoemission. (1)

(ii) **Min** energy required to release a photoelectron from a given metal's surface (1), or product of threshold frequency and Planck's constant (1)

(b) (i) $E_k(\text{max}) = hf - \text{work function}$ ($\frac{1}{2}$)

$$= (6.63 \times 10^{-34} \times 3.5 \times 10^{16}) - 1.8 \times 10^{-17} \quad (\frac{1}{2})$$

$$= 5.2 \times 10^{-18} \text{ J} \quad (1)$$

(ii) $E_k = \frac{1}{2} mv^2$ ($\frac{1}{2}$)

$$v = \sqrt{2E_k/m}$$

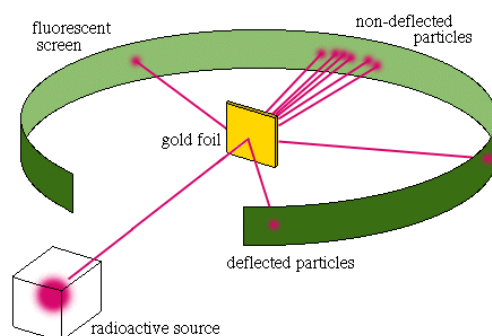
$$= \sqrt{2 \times (5.2 \times 10^{-18}) / 9.11 \times 10^{-31}} \quad (\frac{1}{2})$$

$$= 3.4 \times 10^6 \text{ m/s} \quad (1)$$

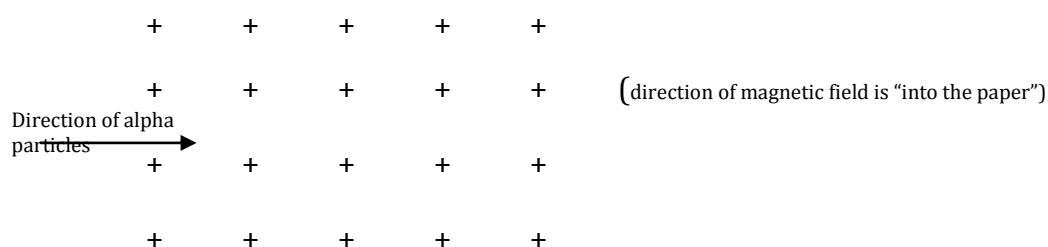
(c) No photoelectrons because frequency of incident light is less than the threshold frequency (1). Could say hf for incident photons is less than the work function (1).

P&W6

In 1909, two scientists called Geiger and Marsden did an experiment where alpha particles from a radioactive source were allowed to strike a thin piece of gold foil.



- (a) Explain how the results of this experiment led to the discovery of the atomic nucleus. 2
- (b) The nucleus is known to contain protons and neutrons, which in turn are made of quarks. State the composition of a proton and neutron in terms of quarks they contain. 1
- (c) Alpha particles can be produced by the radioactive decay of Radium 226. Write down the equation describing this process. 2
- (d) Alpha particles can be deflected in a magnetic field. Copy the diagram below, showing clearly the path of the alpha particles as they pass into the magnetic field. 1



- (e) An alpha particle is accelerated across the gap between two parallel metal plates. The alpha particle is initially at rest and there is a p.d. of 10,000 volts across the plates. Calculate the speed of the alpha particle as it reaches the second plate. (mass of alpha particle = 6.64×10^{-27} kg) 2

(8)

Marking scheme - over

P&W 6

Marking scheme

(a) Most of the alphas passed straight through, showing that the gold atoms were mostly empty space. (1)

A few alphas were deflected through large angles, showing that the nucleus had a concentration of positive charge.
(1)

(b) Proton = uud, neutron = udd (2 x ½)
)

(c) ${}_{88}^{226}\text{Ra} \rightarrow {}_{2}^{4}\text{He} + {}_{86}^{222}\text{Rn}$ (½ each number, 1 for symbol)

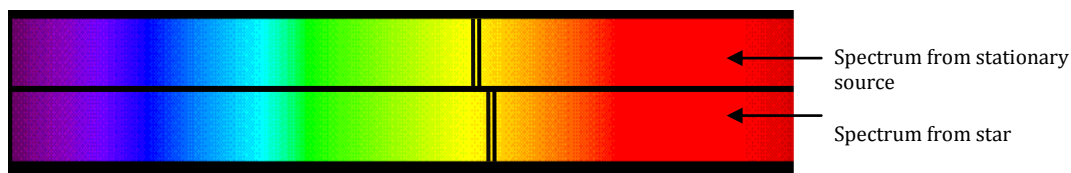
(d) path curves upwards
(1)

(e) $QV = \frac{1}{2} m v^2$ $v = 6.94 \times 10^5 \text{ m s}^{-1}$ (std. 2 marker)

(8)

P&W7

Light from a star is passed through a triangular glass prism to form a spectrum. When compared with light from a stationary source, it is noticed that characteristic lines in the spectrum have been displaced as shown below.



- (a) What does this tell us about the movement of the star? (1)

The wavelength of one of the dark lines, when measured in a laboratory, is 590 nm. When measured using light from the star, the wavelength of the same line is 595 nm.

- (b) Calculate the speed of the star. (3)

- (d) Calculate how far the star is from us. ($H_0 = 2.4 \times 10^{-18} \text{ s}^{-1}$) (2)

- (e) It is also possible to use a diffraction grating to produce a spectrum of the light. State two differences between the spectrum produced by the prism and that produced by the grating. (2)

(a diagram may help)

- (f) If the spectrum containing the dark line is passed through a grating whose spacing is $2 \times 10^{-6} \text{ m}$, calculate the angle at which the dark line in the second order spectrum would be found. (2)

(10)

Marking scheme

- (a) It is moving away from us. (1)

- (b) $z = \frac{\lambda_{obs} - \lambda_{rest}}{\lambda_{rest}} = 8.47 \times 10^{-3}$, $v = z c = 2.54 \times 10^6 \text{ m s}^{-1}$ (3)

- (c) $d = v / H_0 = 1.06 \times 10^{24} \text{ m}$ (2)

- (d) grating has multiple spectra/prism has only one (1)

Red light deviated most with grating/least with prism (1)

- (e) $n\lambda = d \sin\theta$, $2 \times 590 \times 10^{-9} = 2 \times 10^{-6} \times \sin\theta$, $\theta = 36^\circ$ (2)

(10)

Skills Based Questions

SB1

An extract from a student's investigation diary is shown.

Investigation - Compound Pendulum

We carried out an experiment to find how the period of swing depends on the distance from the top of the pendulum (point X).

We hung the piece of metal from hole A so that it could swing freely. We set the pendulum swinging and measured the time for 5 complete swings using a stopwatch. We repeated these steps for all of the holes in the piece of metal using a ruler to measure the distance from point X.

Here are the results.

X

A •
B •
C •
D •
E •
F •

Y

Hole	Distance from X (cm)	Time for 5 swings (s)
A	5	5.56
B	10	5.01
C	14	5.65
D	18	5.88
E	20	6.83
F	22	8.52

The student has taken six sets of readings and used the results to reach a conclusion.

(a) Sketch a graph of the results.

2

(b) Using the information from your sketch graph write a conclusion for the experiment.

2

(c) Suggest two improvements that the student could have made to the collection of data for this investigation.

2

(6)

SB2

An extract from a pupil's lab book is shown below :

Investigation : projectile Motion

Today we carried out experiments to investigate how the range of a projectile varies with the angle it was fired at .

Results :

Range (m)	Angle ($^{\circ}$)
26.4	20
35.2	30
40.1	40
40.2	50
35.3	60
26.2	70

- Sketch a graph of the results (2)
- What conclusion can you draw from the results? (1)
- Suggest two improvements the student could make to the collection of data. (2)
- Suggest another experiment that the pupil could carry out to further improve their understanding of projectile motion. (1)
- Calculate the largest % uncertainty in the angle data . (2)

8

Marking scheme

- Graph must have axes labelled and origin (1)
Shape of graph correct (1) must be a parabola.
- The range reaches a maximum at 45° (1)
- Repeat measurements (1) and more data collected between 40 and 50° (1)
- Initial velocity against range or mass of projectile against range (1)
- Largest % uncertainty is in the smallest angle
Reading uncertainty estimated at 1° ($\frac{1}{2}$)
% uncertainty = (Uncertainty / reading) * 100% ($\frac{1}{2}$)
% uncertainty = $(1 / 20) * 100 = 5\%$ (1)
Accept uncertainty of 0.5° which would give 2.5%

SB3

A black hole is an object where the gravity is so powerful that nothing, not even light can escape it. They're called black holes because they emit no radiation. If you take any object and compress it down, there will be a point that it becomes a black hole. That radius is called the Schwarzschild Radius. The term was named after the mathematician

Karl Schwarzschild, who first developed the formula: $R_s = \frac{2GM}{c^2}$

M is the mass of the body, G is the universal constant of gravitation, and c is the speed of light.

You can use this formula to calculate the Schwarzschild radius of any object.

a) Use this information to complete the table :

Object	Mass (kg)	Schwarzschild Radius (m)
Earth	6.0×10^{24}	8.9×10^{-3}
Moon	7.4×10^{22}	
Sun		4.5×10^3

(3)

b) Two physicists, Oppenheimer and Synder have shown that if a star has at least 3.2 times the mass of our sun then it can form a black hole at the end of its life. Calculate the minimum mass a star must have to form a black hole. (2)

5

Marking scheme

a) Moon $R_s = \frac{2GM}{c^2}$ $R_s = \frac{2 \times 6.67 \times 10^{-11} \times 7.4 \times 10^{22}}{9 \times 10^{16}} = 1.1 \times 10^{-4} m$
(½) (1)

Sun $R_s = \frac{2GM}{c^2}$ $4.5 \times 10^3 = \frac{2 \times 6.67 \times 10^{-11} M}{9 \times 10^{16}} \Rightarrow M = 3.0 \times 10^{30} kg$
(½) (1)

b) Min mass = 3.2 x mass of sun (½)

Min mass = 3.2 x 3.0×10^{30} = $9.6 \times 10^{30} kg$
(½) (1)

SB4

A pupil conducts an experiment to determine the acceleration due to gravity by using a pendulum. The pupil measures the length of the pendulum and then times a single swing of the pendulum for each length to obtain the period.

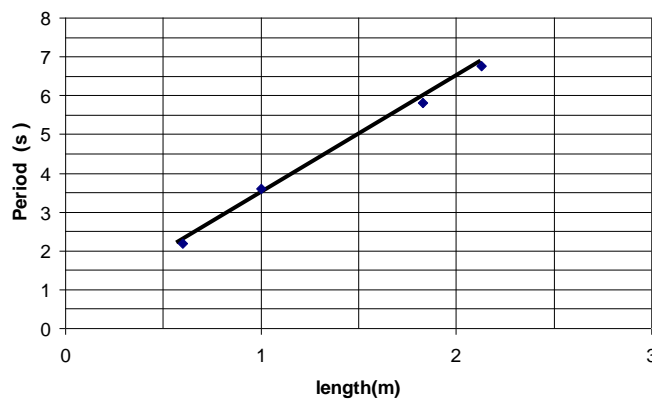
An extract from the pupil's notebook is given.

The relationship relating length to period is given below.

$$T = 2\pi \sqrt{\frac{l}{g}}$$

length (m)	Period (s)
2.13	2.75
1.83	2.63
1.00	1.90
0.6	1.41

The pupil plots a graph of T^2 against length and this is shown.



(a) Show that the expression for the gradient is $m = 4\pi^2/g$ (1)

(b) Calculate the value for 'g' that the pupil would obtain from their graph. (3)

(c) Give **two** ways in which the pupil could have conducted their experiment to obtain a more reliable value for 'g'. (2)

Mark Scheme

(a) square relationship to obtain $T^2 = 4\pi^2 l/g$ (½)

$$m = T^2/l = 4\pi^2/g \quad (½)$$

(b) $m = T_2^2 - T_1^2/l_2 - l_1$

$$= 6.5 - 3.5/2 - 1 = 3 \quad (2)$$

$$3 = 4\pi^2/g$$

$$g = 4\pi^2/3 = 39.5/3 = 13.1\text{m/s}^2 \quad (1)$$

(c) The pupil could:

- time a multiple number of swings to determine period
- repeat measurements of period at each length
- measure the period for a greater number of length measurements.

Any two answers for 1 mark each.

(2)

SB 5

A cyclotron is a machine that is designed to accelerate massive charged particles to high energy levels and use them to bombard targets.

The quantity known as the cyclotron frequency, f , measured in hertz, is given by the equation:

$$f = [q/(2\pi m)] \times B$$

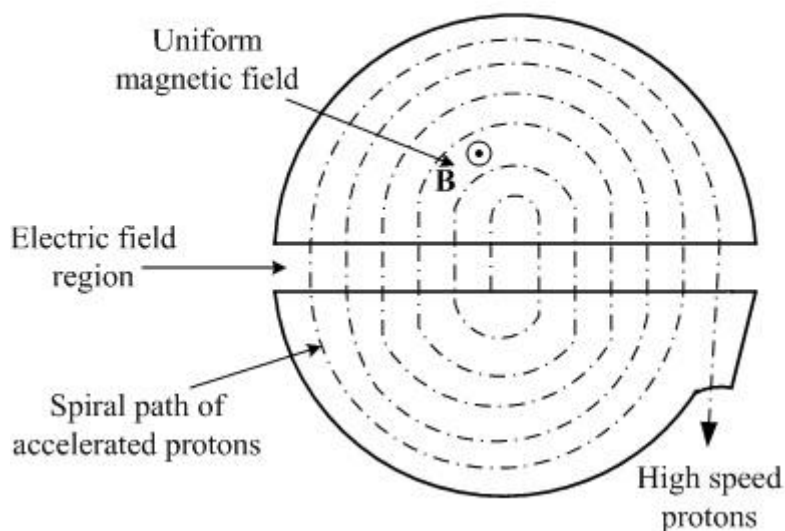
q = charge on particle (C)

m = mass of particle (Kg)

B = Magnetic Induction (Tesla, T)

- (a) Calculate the cyclotron frequency for a proton of mass 1.67×10^{-27} Kg in a magnetic field of 1.5T.
- (b) Sketch a graph of cyclotron frequency, f , on the y - axis, versus magnetic induction, B , on the x - axis. Numerical values are not required on this graph. Assume that the particle has a fixed mass and charge.
- (c) What quantity is represented by the gradient of this graph?

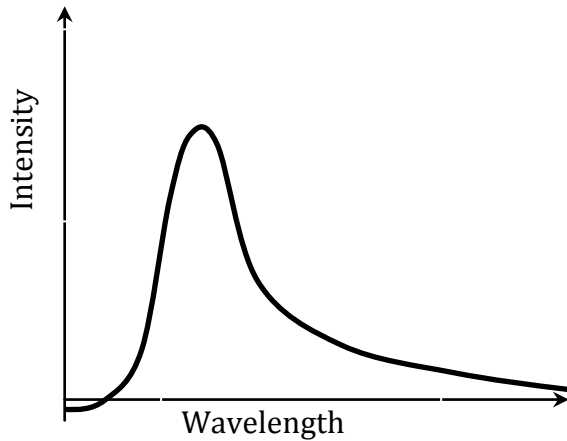
Cyclotron



Multiple Choice Questions

MC1

A graph of Intensity against wavelength for a star with a surface temperature of 10,000 kelvin is shown below



Which of the following statements is true for a star with a surface temperature of 7,000 kelvin?

- (I) The peak wavelength will be longer.
- (II) The peak intensity will be lower.
- (III) The peak intensity will be higher.

- A (I) only
- B (I) + (II)
- C (I) + (III)
- D (II) + (III)
- E (III) only

MC2

The siren on a fire engine has a frequency of 260 Hz. The fire engine is moving away from a stationary observer at 36 km h⁻¹. The frequency heard by the observer is

A 235 Hz

B 253 Hz

C 260 Hz

D 268 Hz

E 291 Hz

Answer – B

MC3

Hadrons are composite particles made of quarks. *Up (u)* quarks have a charge of $+\frac{2}{3}e$ whilst *down (d)* quarks have a charge of $-\frac{1}{3}e$, where e is equal to the magnitude of an electron's charge. Antiquarks have the opposite charge to these values.

Which line in the following table of data on hadrons is correct?

	<i>Hadron</i>	<i>Quark structure</i>	<i>Charge (e)</i>
A	Proton	udd	+1
B	Proton	ddd	+1
C	Neutron	uū	0
D	Neutron	uud	+1
E	Neutron	udd	0

Correct answer = E

MC4

The distance between the Earth and the Moon is 3.84×10^8 m. The mass of the Earth is 5.98×10^{24} kg and the mass of the Moon is 7.35×10^{22} kg. The gravitational force between the Earth and the Moon is

- a) 2.74×10^{-3} N
- b) 1.99×10^{20} N
- c) 7.63×10^{28} N
- d) 2.98×10^{30} N
- e) 1.14×10^{39} N

Answer – B

MC5

A car travelling at 28 ms^{-1} towards a stationary pedestrian sounds a 1000 Hz horn. What frequency will the pedestrian hear as the car approaches ?

Speed of sound through air = 340 m s^{-1}

- A 1082 Hz
- B 1111 Hz
- C 1000 Hz
- D 924 Hz
- E 918 Hz

MC6

A pupil makes the following statements about a star receding from earth :

- 1 The light from the star will be red shifted
- 11 The light from the star will be shifted to a higher wavelength
- 111 The light from the star is shifted to a lower frequency

Which statement(s) is / are correct ?

- A 1 only
- B 11 only
- C 111 only
- D 1 and 11 only
- E 1, 11 and 111

MC7

Estimate the force of gravity acting between two people 1 metre apart.

- A 10^0 N
- B 10^2 N
- C 10^4 N
- D 10^{-7} N
- E 10^{-12} N

MC8

The universe has constantly cooled down as it expands. The temperature of the universe can be calculated by measuring the peak wavelength of background :

- A Infra Red
- B Radio waves
- C Ultra Violet
- D Microwaves
- E X - rays

MC9

A missile is fired at 100 ms^{-1} east from a tank travelling at 30 ms^{-1} east. The velocity of the missile relative to the stationary target is :

- A 100 ms^{-1}
- B 70 m s^{-1}
- C 130 ms^{-1}
- D 30 m s^{-1}
- E 0 m s^{-1}

MC10

A car accelerates from rest to 25 ms^{-1} in 8.0 seconds. To the most appropriate number of significant figures, its acceleration and the distance covered in this time are:

- (a) 3.125 ms^{-2} and 100m
- (b) 3.130 ms^{-2} and 100.0m
- (c) 3.1 ms^{-2} and 100m
- (d) 3.10 ms^{-2} and 200m
- (e) 3.10 ms^{-2} and 100m

MC11

When at rest the particle has a life-time t . Once formed in the upper atmosphere the particle moves towards the surface at a speed of $2.9 \times 10^8 \text{ ms}^{-1}$. The particle's lifetime is measured by an observer on the Earth.

Which row in the table describes the life-time measured in the particle's frame of reference and by the observer on Earth?

	<i>Life-time measured in particle's frame of reference</i>	<i>Life-time measured by observer on Earth</i>
A	t	Less than t
B	t	t
C	Less than t	t
D	t	Greater than t
E	Greater than t	t

MC12

A starship at rest to an observer is 12 metres long. The starship then travels past the observer at $0.8c$. How long does the starship appear to be to the observer when in motion?

A 7.2 m

B 12 m

C 13.5 m

D 16.4 m

E 15.2 m