South Australian
Certificate of Education

Stage 2 Physics

Sample Examination Questions

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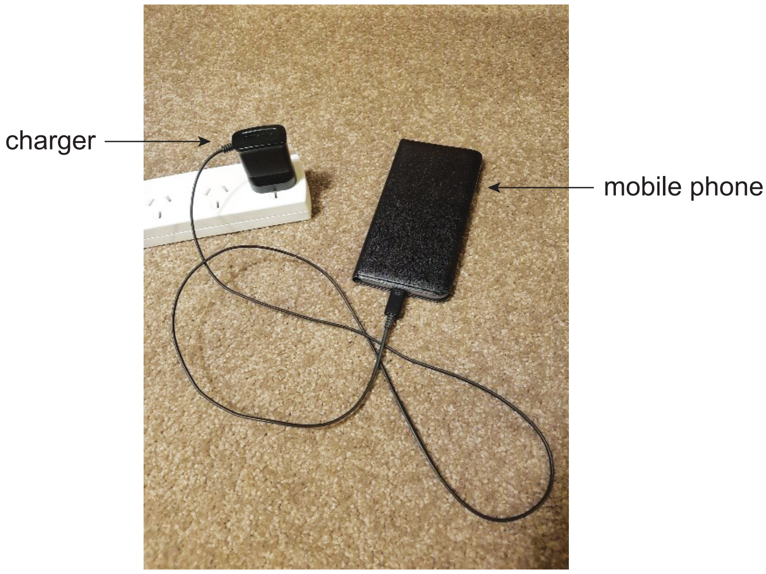
1. The photograph below shows a mobile phone connected to a charger. The charger contains a step-down transformer.



The transformer decreases the voltage from $220\ \text{V}$ to $5.0\ \text{V}$. The primary coil of the transformer has 3520 turns.

Determine the number of turns in the secondary coil of the transformer.

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____ (2 marks)

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2. Two experiments were conducted to determine the wavelength of light from a monochromatic light source.

(a) In Experiment 1, the light was projected through a diffraction grating.

The distance between the slits in the diffraction grating was 2.0×10^{-6} m. The second-order maximum in the pattern produced occurred at an angle of 39°.

Use the data from Experiment 1 to determine the wavelength of the light.

(3 marks)

(b) In Experiment 2, the same light source was used with a Young's double-slit interferometer.

The distance between the slits was 2.8×10^{-4} m, and the slit-to-screen distance was 0.25 m. The distance between adjacent maxima on the screen was 5.5×10^{-4} m.

Use the data from Experiment 2 to determine the wavelength of the light.

(3 marks)

(c) The label on the light source indicated that the light had a wavelength of 633 nm.

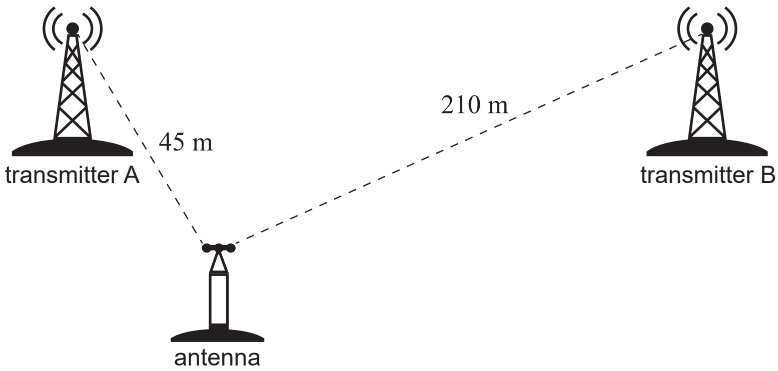
State which experiment, Experiment 1 or Experiment 2, produced the more accurate result.

(1 mark)

3. Two transmitters, A and B, emitted signals that were in phase. The wavelength of each signal was $30\ \text{m}$.

An antenna received signals from both transmitters.

The antenna was $45\ \text{m}$ from transmitter A and $210\ \text{m}$ from transmitter B, as shown in the diagram below.



[This diagram is not drawn to scale.]

Explain whether the antenna was at a location of maximum amplitude or minimum amplitude.

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____ (4 marks)

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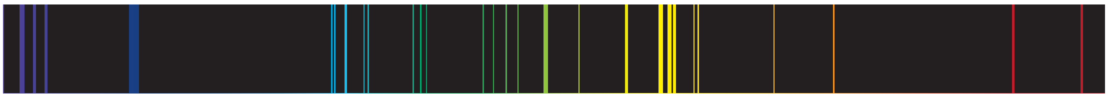
4. The heated vapour of a single element emits light of discrete frequencies, resulting in a line emission spectrum that can be seen when the light is viewed with a spectrometer.

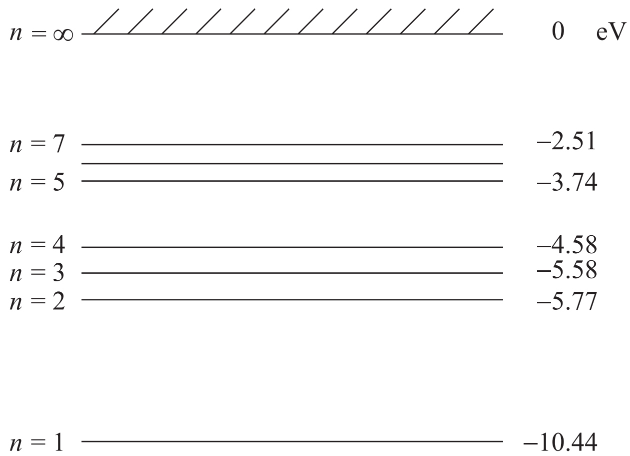
The photograph below shows the line emission spectrum of mercury.



(a) Explain how line emission spectra provide evidence for discrete energy states in atoms.

____ (3 marks)

(b) The diagram below shows some of the energy levels of mercury.



[This diagram is not drawn to scale.]

Determine the wavelength of the photon that is emitted when an electron in a mercury atom makes a transition from the $n = 7$ energy level to the $n = 3$ energy level.

(5 marks)

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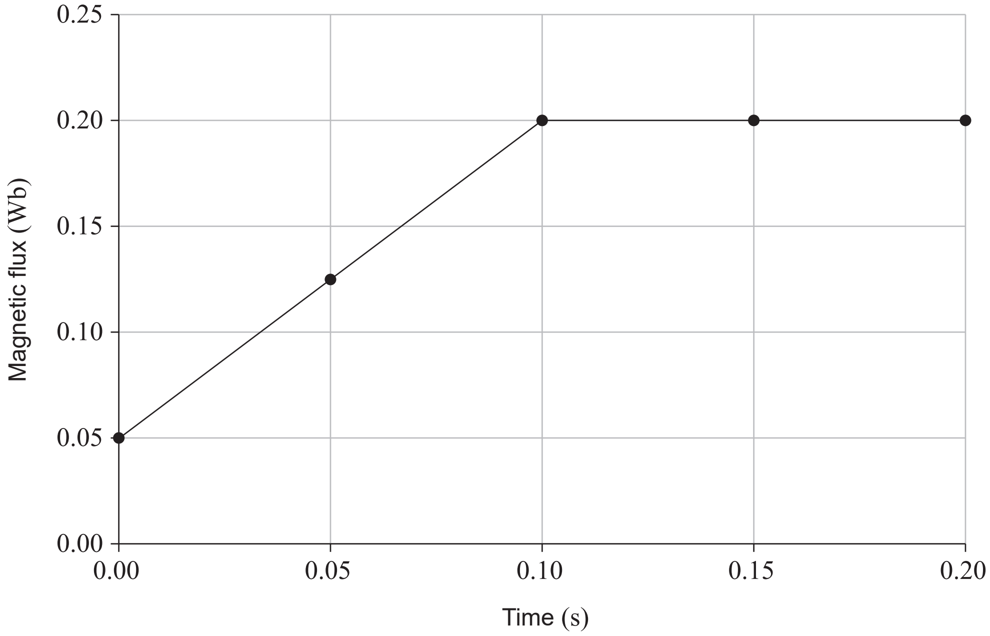
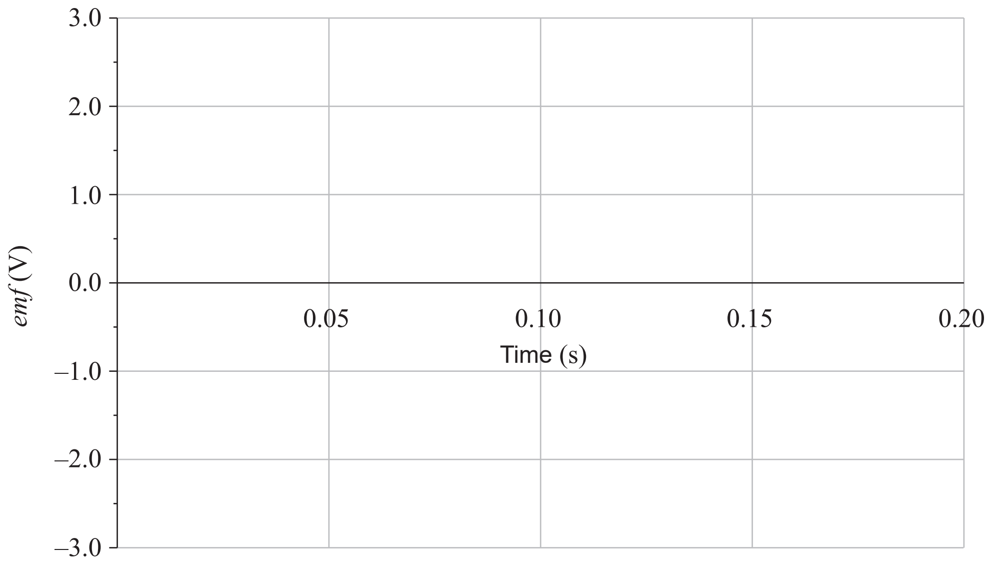
5. A single conducting loop was positioned within a magnetic field. The strength of the magnetic field was adjusted, resulting in a change in the magnetic flux through the conducting loop.

The graph below shows how the magnetic flux changed over time.



On the axes below, sketch a graph that shows the induced *emf* within the conducting loop.



(2 marks)

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6. The *Fengyun 2-07* satellite is a weather satellite that is in a geostationary orbit around the Earth.

(a) State *three* features of a geostationary orbit.

(3 marks)

(b) Determine the radius of the orbit of the *Fengyun 2-07* satellite.

(4 marks)

(c) Suggest why, once its useful life has expired, scientists may increase the speed of the *Fengyun 2-07* satellite.

(2 marks)

7. Some organisations plan to build scientific bases on the planet Mars.

Mars has a mass of 6.4×10^{23} kg and a mean radius of 3.4×10^{6} m.

(a) Using Newton's Law of Universal Gravitation and Second Law of Motion, show that the magnitude of gravitational acceleration at the surface of Mars is approximately 3.7 m s^{-2}.

(2 marks)

(b) Once the scientific bases have been built on Mars, they will be able to support scientists. The scientists will conduct various tests, including launching a projectile upwards in order to measure atmospheric conditions at different heights.

The projectile will be launched at a velocity of $1.3 \times 10^{3} \text{ m s}^{-1}$ at an angle of 85° above the horizontal.

Determine the range of the projectile.

Ignore air resistance.

(5 marks)

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(c) Determine the speed that a satellite would need to have in order to orbit Mars in a circular path of radius 4.2×10^7 m.

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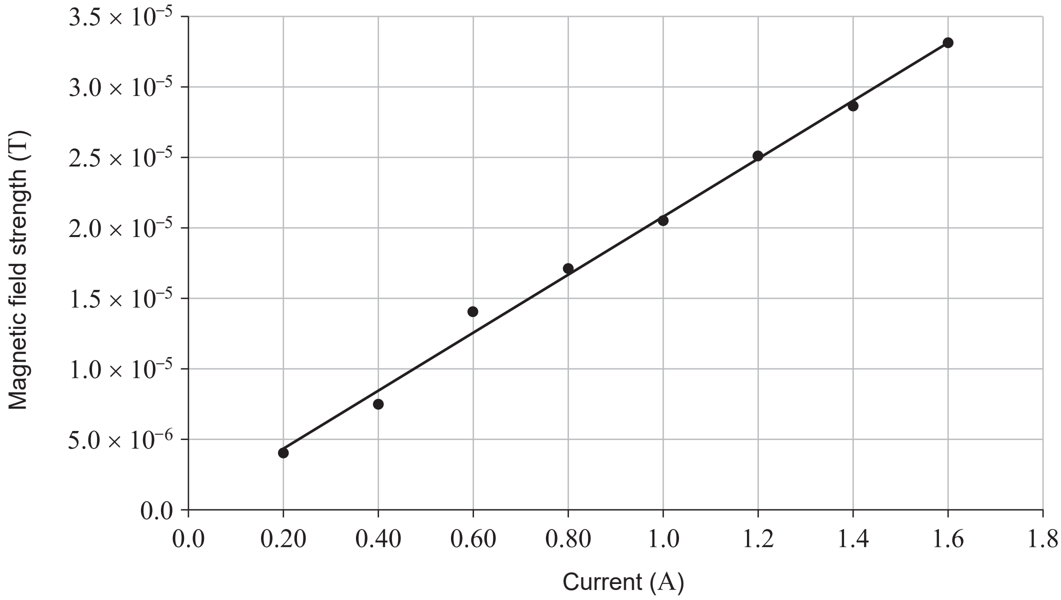
____ (2 marks)

8. A group of students conducted an experiment to explore the magnetic field that was produced by a long, straight current-carrying conductor. They positioned a magnetic field strength detector at a fixed distance from the centre of the conductor, and measured the strength of the magnetic field when each different current flowed through the conductor.

The data collected by the students are shown in the graph below.



(a) Explain whether or not the graph shows the presence of significant random errors.

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____ (2 marks)

(b) The line of best fit for the data points has a gradient of 2.1×10^{-5} TA^{-1}, and would intersect the vertical axis at 1.7×10^{-7} T.

(i) Explain whether or not the vertical axis intercept of 1.7×10^{-7} T shows the presence of a significant systematic error.

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____ (2 marks)

(ii) Using the gradient of the line of best fit, determine the distance between the magnetic field strength detector and the centre of the conductor.

(3 marks)

9. A cyclotron was used to accelerate protons to high energies.

(a) The cyclotron has a radius of 0.42 m. The magnetic field of the cyclotron has a magnitude of 1.4 T.

Calculate the kinetic energy of the protons as they emerged from the cyclotron. Give your answer in MeV.

(3 marks)

(b) Describe the purpose of the electric field and the purpose of the magnetic field in accelerating the protons to high energies.

(3 marks)

(c) Explain why the protons do ***not*** gain kinetic energy when inside the dees.

(2 marks)

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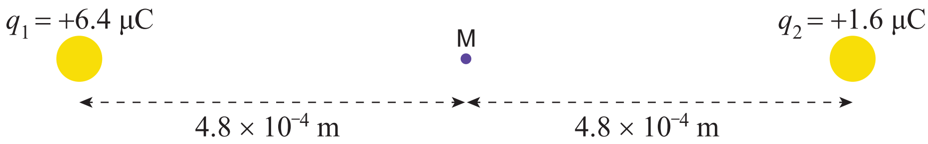
10. The diagram below shows two point charges, q_1 and q_2, positioned in a vacuum. The charge of q_1 is $+6.4\ \mu C$ and the charge of q_2 is $+1.6\ \mu C$.

A proton is positioned at point M, which is exactly midway between the charges, on the line joining their centres.



[This diagram is not drawn to scale.]

(a) (i) Calculate the magnitude of the electric force that q_1 exerts on the proton at point M.

(2 marks)

(ii) Determine the magnitude of the electric force that q_2 exerts on the proton at point M.

(2 marks)

(iii) Hence determine the magnitude and the direction of the net electric force on the proton.

(2 marks)

(b) Show that the proton must be positioned twice as far from q_1 than from q_2 in order for the net electric force on the proton to be zero.

(2 marks)

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11. A projectile was launched at speed v, at an angle of $30°$ above the horizontal. The same projectile was then launched at speed v, but at an angle of $45°$ above the horizontal.

Ignore air resistance in both parts of this question.

(a) State which launch angle would have resulted in the projectile reaching the greater maximum height. Explain your answer.

(3 marks)

(b) Explain why increasing the launch height would increase the range of the projectile.

(2 marks)

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12. X-rays can be used to study artwork. X-rays are used to penetrate the outer painted layer of an artwork, allowing art experts to view any existing underlying layers of paint that may no longer be visible to the human eye.

Scientists at an art museum decided to use X-rays with a low penetrating power so that they penetrate only the outer painted layer of artworks.

(a) Explain why the X-rays that are produced by a simple X-ray tube have a range of frequencies.

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____ (3 marks)

(b) Explain whether or not X-ray photons that have high frequencies are suitable for viewing any existing underlying layers of paint.

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____ (3 marks)

(c) The scientists decided to use X-rays of a maximum frequency of 1.2×10^{18} Hz.

Determine the potential difference across the X-ray tube that will produce X-rays of a maximum frequency of 1.2×10^{18} Hz.

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____ (3 marks)

13. Muons are subatomic particles. The lifetime of a muon that is moving at speed v is different in the frame of reference of the muon and in the frame of reference of a stationary observer.

Two values of the lifetime of the muon are $2.197\ \mu s$ and $64.44\ \mu s$.

(a) Identify which *one* of these two lifetimes would have occurred in the frame of reference of a stationary observer. Justify your answer.

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____ (2 marks)

(b) Use the two lifetimes to determine the speed v of the muon.
Give your answer as a percentage of the speed of light, to four significant figures.

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____ (3 marks)

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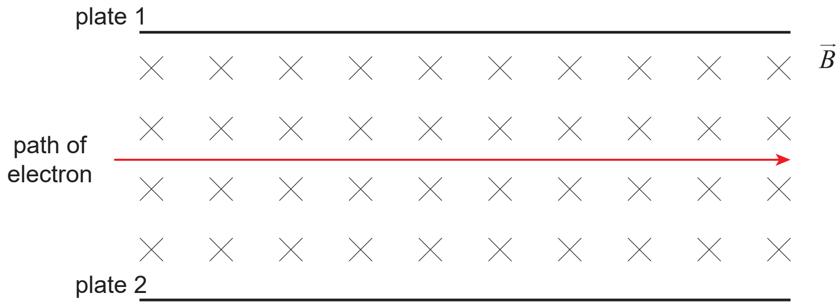
14. An electron was projected into a region that contained perpendicular electric and magnetic fields. The electric field was created by two oppositely charged parallel plates, plate 1 and plate 2.

The magnetic field $\vec{B}$ was directed into the page.

The electron travelled in a straight line when it was within this region, as shown in the diagram below.



[This diagram is not drawn to scale.]

(a) Identify which plate, plate 1 or plate 2, must have been positive in order to cause the electron to travel in a straight line when it was within both the electric field and the magnetic field. Justify your answer.

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____ (2 marks)

The parallel plates were 0.025 m apart, and had a potential difference of 3400 V between them.

The magnitude of the magnetic field was $8.0 \times 10^{-3} \text{ T}$.

(b) Show that the electron must have travelled at a speed of $1.7 \times 10^{7} \text{ m s}^{-1}$ in order to have moved in a straight line when it was between the parallel plates.

Assume that the electric and magnetic fields are located in a vacuum, and ignore the effect of gravity.

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____ (3 marks)

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The electron moved out of the region between the two plates, so was no longer in the electric field. It continued moving through the magnetic field at a constant speed, and in a circular path, as shown in the diagram below.

[This diagram is not drawn to scale.]

(c) (i) Explain why the electron travelled both at a constant speed, and in a circular path, when it was moving through only the magnetic field.

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____ (3 marks)

(ii) Calculate the radius of the path of the electron when it was moving through only the magnetic field.

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____ (2 marks)

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15. A photoelectric effect experiment was conducted using three monochromatic light sources: A, B, and C. Light from source A was projected at a metal surface and the maximum speed of any emitted electrons was determined. This was repeated with light from source B and then with light from source C.

The results of the experiment are shown in the table below.

Light source	*Wavelength of incident light* (nm)	*Observation*	*Maximum speed of emitted electrons* ($m\,s^{-1}$)
A	400	electrons emitted	6.22×10^5
B	550	electrons emitted	2.99×10^5
C	700	no electrons emitted	not applicable

(a) (i) Explain why light from sources A and B caused electron emission from the metal surface, but light from source C did not.

(2 marks)

(ii) Explain why the electrons emitted when using light from source A had a higher maximum speed than those emitted when using light from source B.

(2 marks)

(b) Using data from the table above, determine the work function of the metal surface.

(3 marks)

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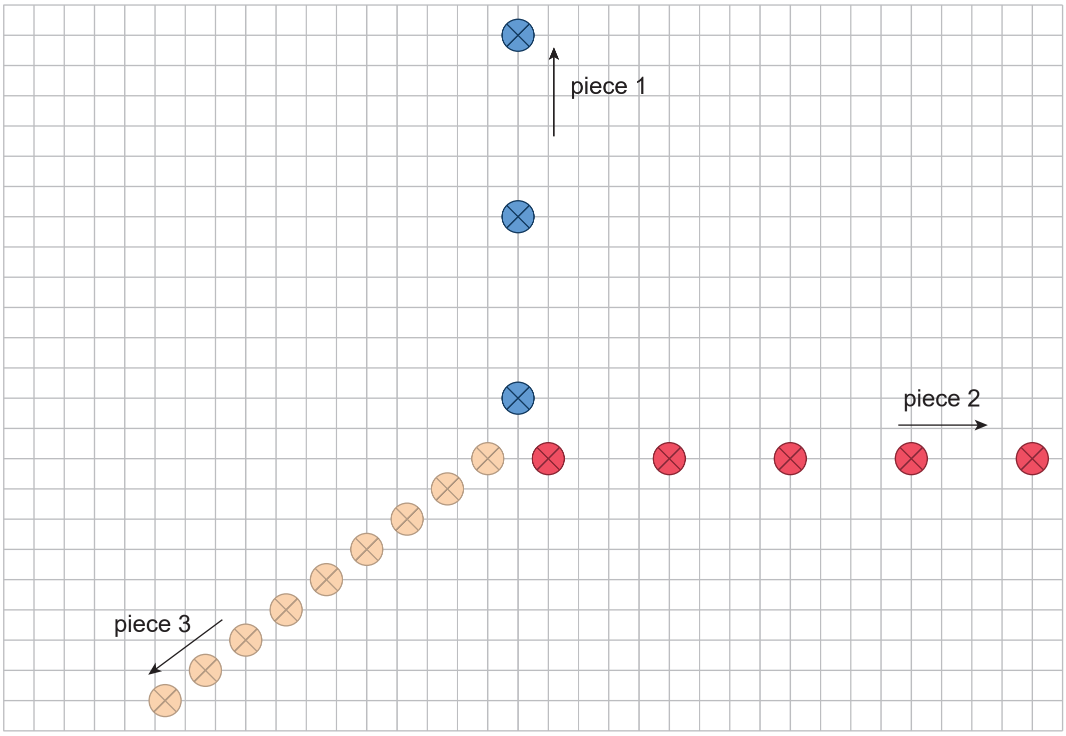
16. A stationary object exploded into three pieces. Piece 1 had a mass of m, piece 2 had a mass of $2m$, and piece 3 had a mass of $6m$.

The multi-image diagram below shows the motion of the three pieces after the explosion.

Assume that the system is isolated, and that the time between each image was constant.



(a) On the diagram above, draw and label the momentum vectors for piece 1, for piece 2, and for piece 3. (2 marks)

(b) With the aid of a vector diagram, show that momentum was conserved in this explosion.

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____ (3 marks)

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17.

> In 1950, scientists from the University of Melbourne discovered a subatomic particle by examining cosmic ray interactions. This particle is now named the 'lambda particle'. The lambda particle was found to have a mass greater than that of a proton, so it was classified as a baryon. Over the following decades other baryons were discovered, including the Xi particles and the omega particles.
>
> The accepted theories at the time of its discovery suggested that the lambda particle would have a lifetime of approximately 10^{-23} seconds. However, experiments found that its lifetime was approximately 10^{-10} seconds. This 'strangeness' led to one of the three quarks in the lambda particle being named the 'strange quark'.
>
> In 1963, physicist Eric Burhop predicted the existence of a new type of lambda particle: the charmed lambda particle. Wikipedia states that 'In 1974 and 1975, an international team at the Fermilab that included scientists from Fermilab and seven European laboratories under the leadership of Eric Burhop carried out a search for [the] new particle'. The charmed lambda particle was successfully discovered, and its existence was confirmed in other experiments.

Source: Wikipedia contributors 2019, 'Lambda baryon', *Wikipedia, the free encyclopedia*, viewed 22 January 2020, https://en.wikipedia.org/wiki/Lambda_baryon

(a) The neutral lambda particle, Λ^0, contains three quarks. One of these quarks is an up quark and another is a strange quark.

Based on this information, determine all of the possible types of quark that the third quark could be.

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___ (3 marks)

(b) The decay of a neutral lambda particle, Λ^0, produces a negative pi meson, π^-, and a positive particle.

Explain why this positive particle could ***not*** be a positive pi meson.

(2 marks)

(c) Using the information on page 10, describe *three* examples of how the discovery of lambda particles and their properties demonstrates science as a human endeavour.

(6 marks)

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