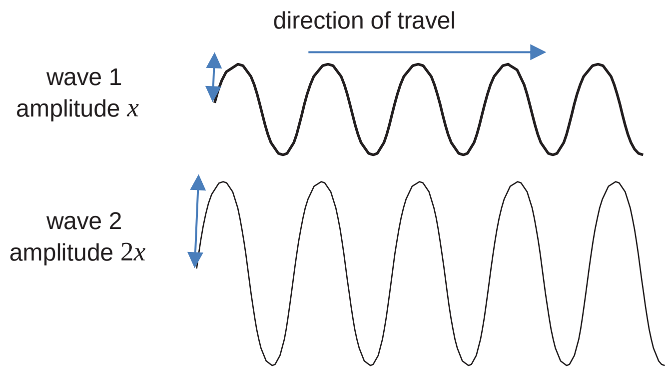
Stage 2 Physics

The following examination-style questions are suitable for assessing evidence of learning in **Topic 3**.

They do not constitute a complete test.

1. The diagram below shows two vertically polarised electromagnetic waves that are travelling to the right of this page. The two waves have the same wavelength but different amplitudes.



Wave 1 has an amplitude of x, and wave 2 has an amplitude of $2x$. Both waves are received by an antenna.

(a) State the orientation of the magnetic fields of the electromagnetic waves.

____ (1 mark)

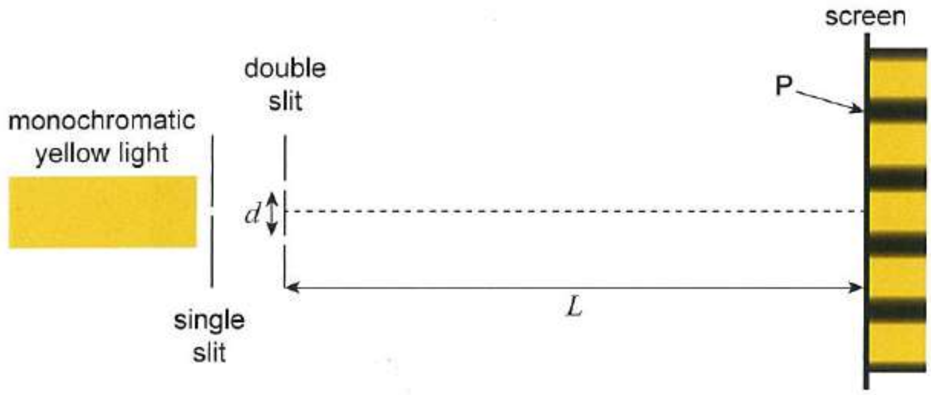
(b) State the orientation of the receiving antenna that would result in optimal reception of the electromagnetic waves.

____ (1 mark)

(c) The waves are in phase at the antenna. State the resultant amplitude.

____ (1 mark)

2. A group of students conducts an experiment to investigate the interference of light. The students use a two-slit interference apparatus and a lamp that produces monochromatic yellow light of wavelength 589.3 nm.



[*This diagram is not drawn to scale.*]

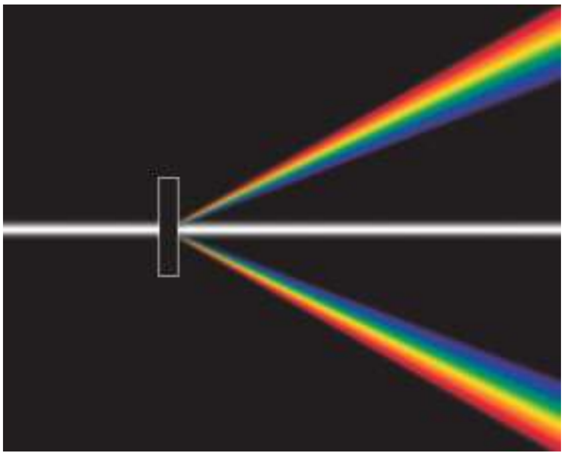
(a) A point of minimum intensity is observed at point P on the screen.
Determine the path difference from the double slit to P. Justify your answer.

(2 marks)

(b) The students remove the single slit.
Explain what they will now observe on the screen.

(2 marks)

92 The image below shows what is observed when white light is incident on a diffraction grating.



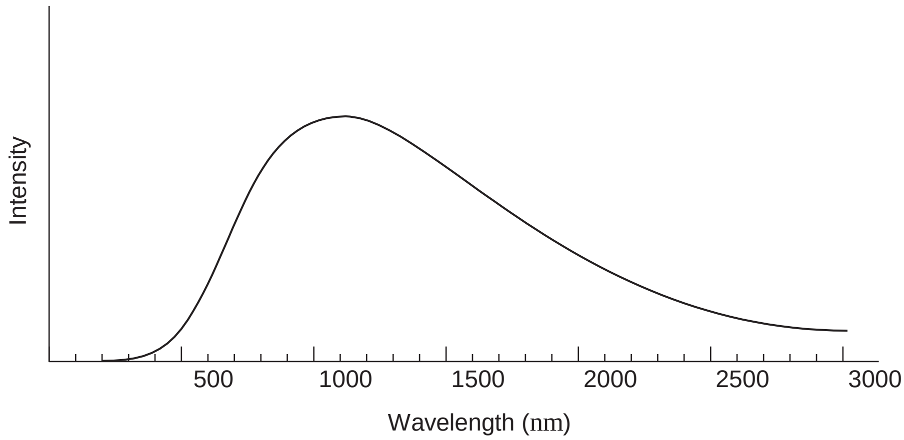
Explain why white light is observed at the central maximum, whereas a range of colours is observed at the first-order maxima.

(2 marks)

93 The photograph below shows a filament globe.

Source: © Ezumeimages | Dreamstime

The graph below shows the spectrum produced by a hot filament.



Source: Adapted from © http://electronicdesign.com/components/leds-line-replace-residential-incandescent-bulbs

(a) Explain why a continuous range of wavelengths is produced by the hot filament.

(2 marks)

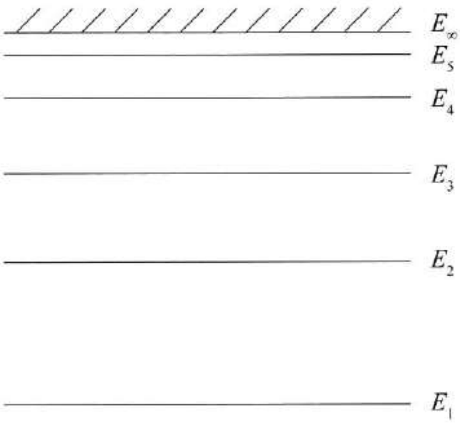
(b) *On the graph above*, draw the spectrum that would be produced by the filament if its temperature were increased.

(2 marks)

5. The cells of some jellyfish produce bright colours when they emit light through fluorescence.

Source: © Don Macdonell | Dreamstime

Using the energy-level diagram of an atom below, describe the process of fluorescence.



[*This diagram is not drawn to scale.*]

(3 marks)

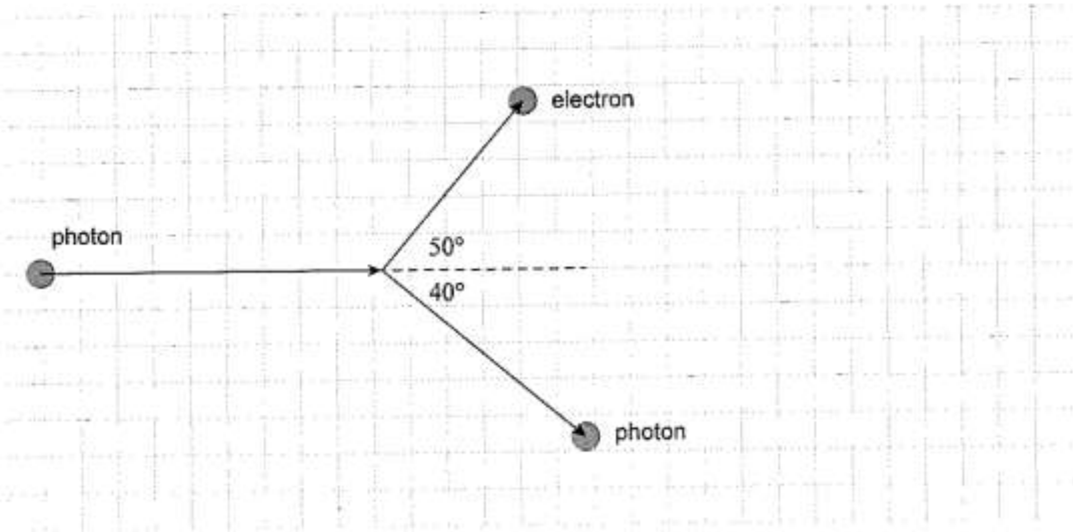
6. A helium–neon gas laser produces light through stimulated emission.

Compare the process of stimulated emission with the process of spontaneous emission.

(4 marks)

7. When a photon collides with an electron, momentum is transferred to the electron, and the frequency of the photon is reduced.

The diagram below shows the momentum vector of a photon before it collides with a stationary electron. The diagram also shows the momentum vectors of the electron and the photon after the collision.



Before the collision, the photon has a frequency of 2.10×10^{19} Hz.

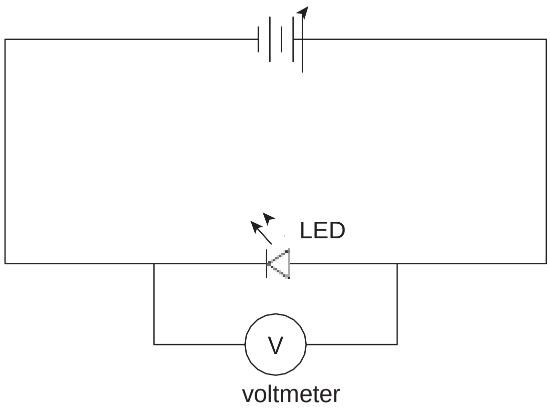
Show that the momentum of the photon before the collision is 4.64×10^{-23} kg m s^{-1}.

(2 marks)

8. A group of students measured Planck's constant using two different methods (A and B).

(a) In **method A**, the students used a circuit consisting of a light-emitting diode (LED) and a variable potential difference, as shown in the diagram below.

The students adjusted the potential difference across the LED until light was emitted, and they used a voltmeter to measure the minimum potential difference V_0 needed for light to be emitted. This was repeated for four other LEDs.



The table below shows the known wavelengths and frequencies of light emitted by each LED and the data collected using method A.

Wavelength emitted by LED λ (nm)	Frequency emitted by LED f ($\times 10^{14}$ Hz)	Minimum potential difference V_0 (V)
690	4.35	1.80
620	4.84	2.00
540	5.56	2.30
475		2.60
420	7.41	3.00

(i) Complete the table by calculating the frequency of light with a wavelength of 475 nm. (1 mark)

(ii) *On the following page* which shows a graph of V_0 (vertical axis) versus f (horizontal axis), plot the value that you calculated in (a)(i) of this question and draw a line of best fit. (3 marks)

(iii) Calculate the slope of the line of best fit. State the units of the slope.

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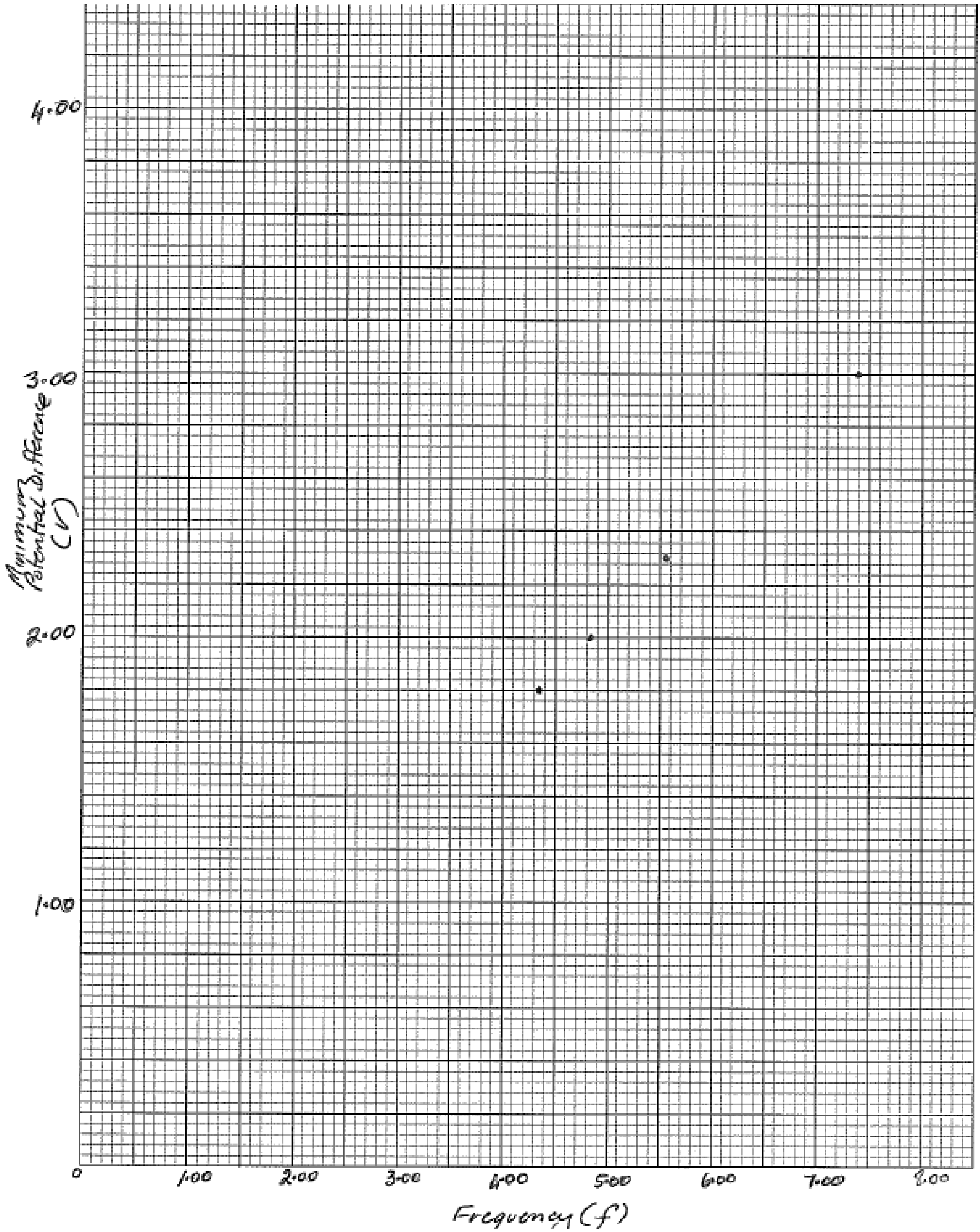
____ (3 marks)

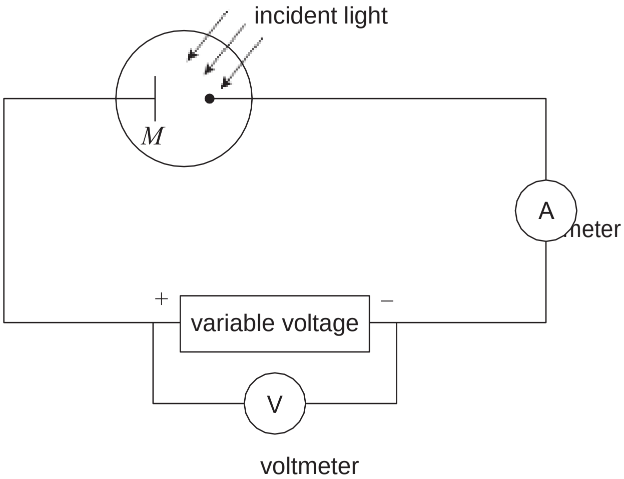

4.00
3.00
Minimum Potential Difference (V)
2.00
1.00
0
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
Frequency (f)

(iv) The relationship between the minimum voltage V_0 and frequency f is given by $eV_0 = hf$. Using the slope of the line of best fit that you calculated in part (a)(iii) on page 14, determine the value of Planck's constant obtained using method A.

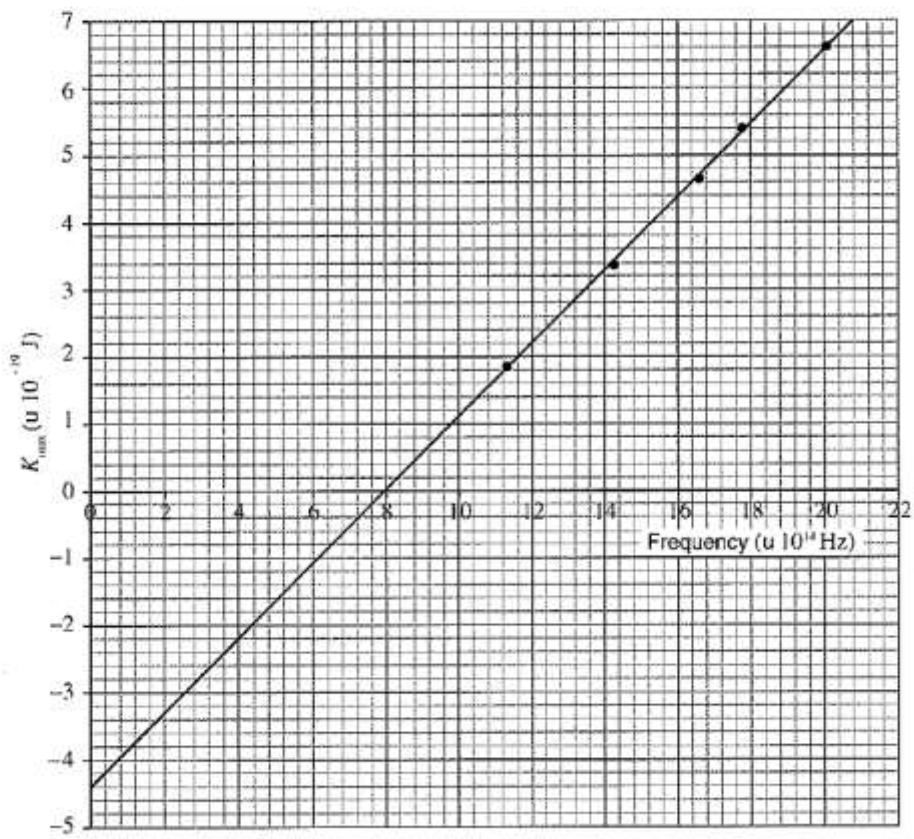
(1 mark)

In method B, the students used a photoelectric effect apparatus, shown in the diagram below, to determine the maximum kinetic energy, K_{max}, of photoelectrons emitted from a metal surface.

Light was shone on the metal surface M, and the variable voltage was increased until the current in the ammeter decreased to zero. This was repeated for light of four other frequencies.



The graph which follows shows the data determined using method B.



(i) State the independent variable in method B. Justify your answer.

(2 marks)

The slope of the line of best fit is 5.5×10^{-34} J s.

(ii) Write the equation of the line of best fit.

(2 marks)

(iii) Hence state the value of Planck's constant obtained using method B.

(1 mark)

(c) The true value of Planck's constant is 6.63×10^{-34} Js.

State which method (A or B) produced the more accurate result. Justify your answer.

(2 marks)

9. Materials such as muscle, bone, and metal attenuate X-rays by different amounts. This allows these materials to be identified in an X-ray image, as shown in the image of an artificial knee joint below.

   X-rays are a type of ionising radiation that can damage living matter.

Source: © Sphotography | Dreamstime

Explain why metal attenuates X-rays more than bone attenuates X-rays.

(6 marks)