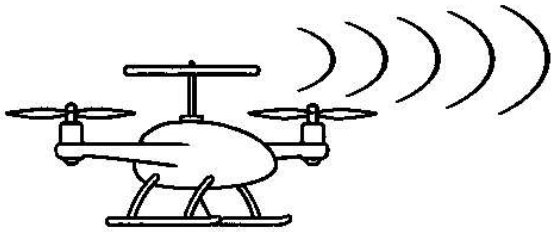
Year 12 Physics NAME_____

Test: Light and Waves

Total marks: 63

Wave Behaviour of Light, Photoelectric Effect, Wave Behaviour of Particles

1. One peer-review study showed that horizontal polarisation improved communication between drones and their controlling ground station.



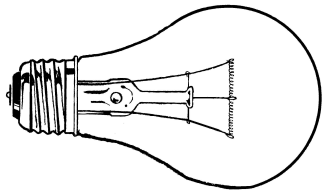
(a) State the best orientation for an antenna to receive horizontally polarised waves.

_____ (1)

(b) State the orientation of the magnetic field oscillation in horizontally polarised waves.

_____ (1)

2. Incandescent light, produced by filament bulbs such as the one below, is neither coherent nor monochromatic.



(a) State what it means for a light source to be coherent.

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(b) Explain why incandescent light is not monochromatic.

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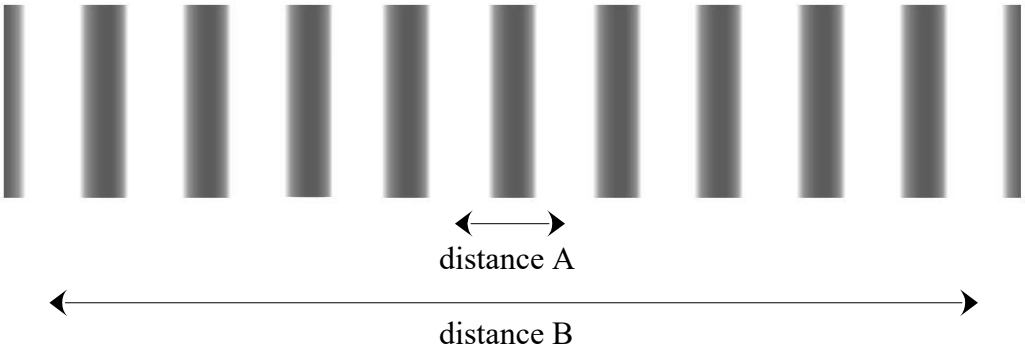
_____(2)

3. Two students conducted a two-slit experiment to determine the wavelength of the red light produced by a laser. The distance between the slits was 1.2×10^{-4} m. The diagram below shows the pattern that was produced on a screen that was positioned 1.9 m from the slits.



When determining the distance between adjacent maxima, one student measured distance A and found that it was 11 mm. The other student measured distance B and found that it was 91 mm.

(a) Explain why measuring distance B demonstrates better experimental skills than measuring distance A.

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_____(2)

(b)

(i) Distance B was used in a calculation of the distance between adjacent maxima. Show that the result was $\Delta y = 1.0 \times 10^{-2}$ m.

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_____(1)

(ii) Determine the wavelength of the light used in the experiment.

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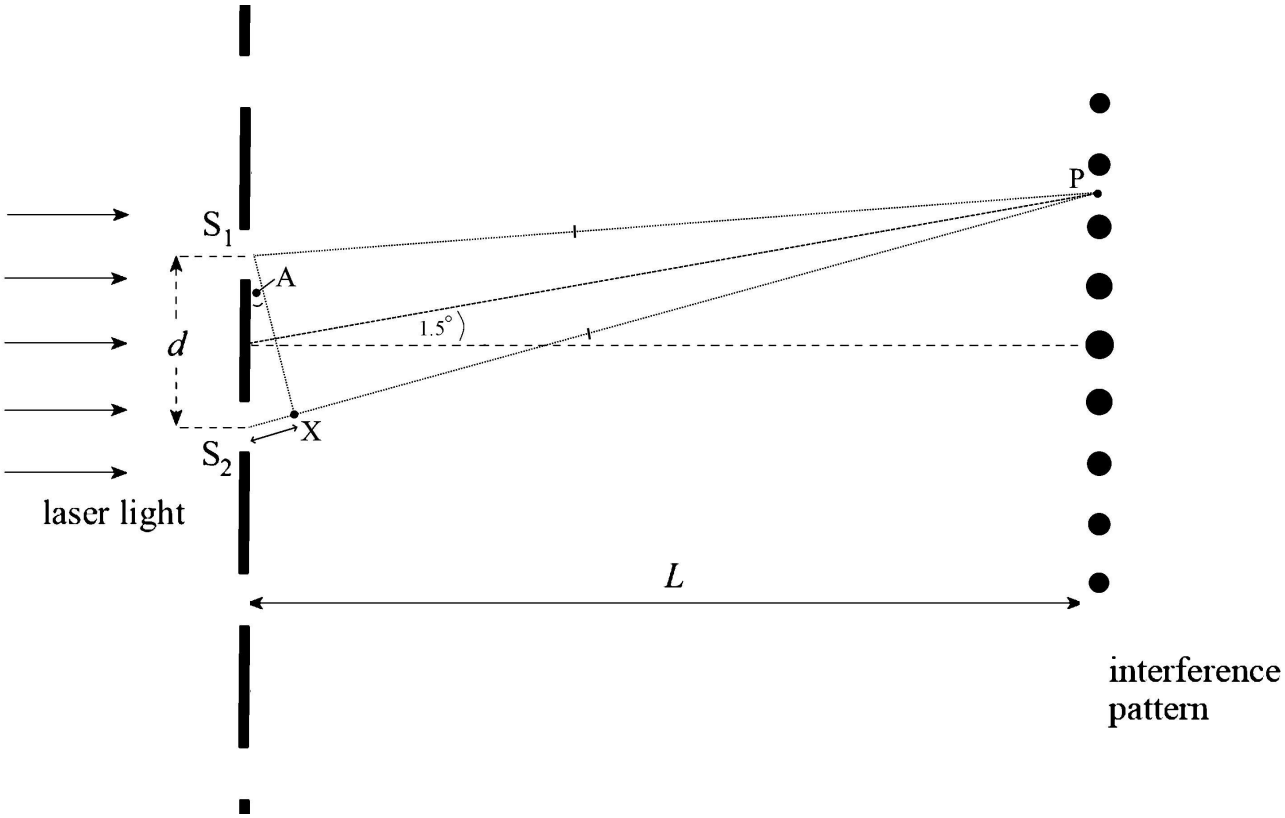
_____(3)

4. A green laser beam with wavelength 532 nm is directed through a diffraction grating. The interference pattern is projected onto a wall, and produces the pattern of green dots in the positions shown below.



(a) A point P has been marked on the pattern halfway between two of the bright spots. Lines from two of the slits to P have been drawn on the diagram and a point X chosen such that the distance from S1 to P and the distance X to P are equal.

(i) Determine the distance between S_2 and X.

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_____(3)

(ii) State the relationship between d and L that causes the lines S_1 to P and S_2 to P to be approximately parallel.

_____(1)

(iii) State the value of the angle labelled A.

_____(1)

(iv) Hence show that this grating has 200 slits/cm.

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_____(4)

(v) Hence determine the maximum order that could be visible for this diffraction grating using this laser.

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_____(2)

(b) Explain why there are areas of negligible intensity between the bright spots.

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_____(2)

(c) State how the observed pattern would change if the size of the openings is increased (whilst keeping the distance *d* between the slits the same as before). Give a reason for your answer.

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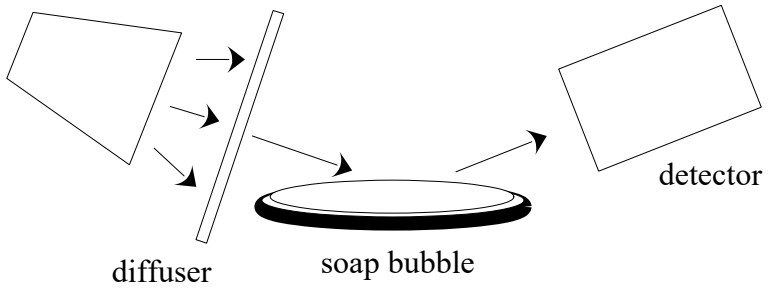
_____(2)

(d) State why the light does not need to be passed through a single slit in order for this pattern to be observed on the wall in this experiment.

_____(1)

5. A group of students investigates the thickness of a soap film by observing interference fringes formed when monochromatic light reflects off different layers of the surface of a soap bubble.



The results of the data collection are shown in the table below:

	Distance *y* from Central Bright Spot (mm)			
Fringe Order *m*	**Trial 1**	**Trial 2**	**Trial 3**	**Average**
0	0.0	0.0	0.0	
1	2.5	2.8	2.5	
2	5.0	5.1	5.8	
3	7.3	7.5	7.6	
4	10	10.1	9.7	

(a) State the entry in the table above which does not follow correct Physics conventions.

_____(1)

(b) Complete the table above by calculating the Average values for each Fringe Order. (2)

(c) State the Fringe Order *m* for which the measurements were least precise.

_____(1)

(d) On graph paper, plot a graph of Average Distance *y* against Fringe Order *m*. Include a line of best fit. (5)

(e) Determine the gradient of your line of best fit, in metres.

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_____ (3)

(f) The relationship between the variables is suspected to be $y = \frac{\lambda}{2\tan\alpha} m$ where α is the angle at the edge of the soap bubble.
Use the gradient calculated above to determine the angle at the edge of the soap bubble, given that the wavelength of light used is 6.05×10^{-7} m.

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_____(3)

(g) The light used in the experiment above was orange.
On your graph, draw and label a line showing how the results would be changed if the light used was closer to the red end of the visible spectrum. (1)

6. Ultraviolet light of frequency 1.9×10^{15} Hz illuminates a sensor. The work function of the sensor is 7.3×10^{-19} J.

(a) Describe and explain the effect that increasing the intensity of the incident ultraviolet light would have on the number and energy of the emitted electrons.

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_____ (3)

(b)

(i) Calculate the maximum kinetic energy of the electrons emitted from the sensor.

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_____ (2)

(ii) A stopping voltage can be used to measure the maximum kinetic energy of the electrons.
Calculate the stopping voltage that would be required to reduce the current to zero in the sensor.

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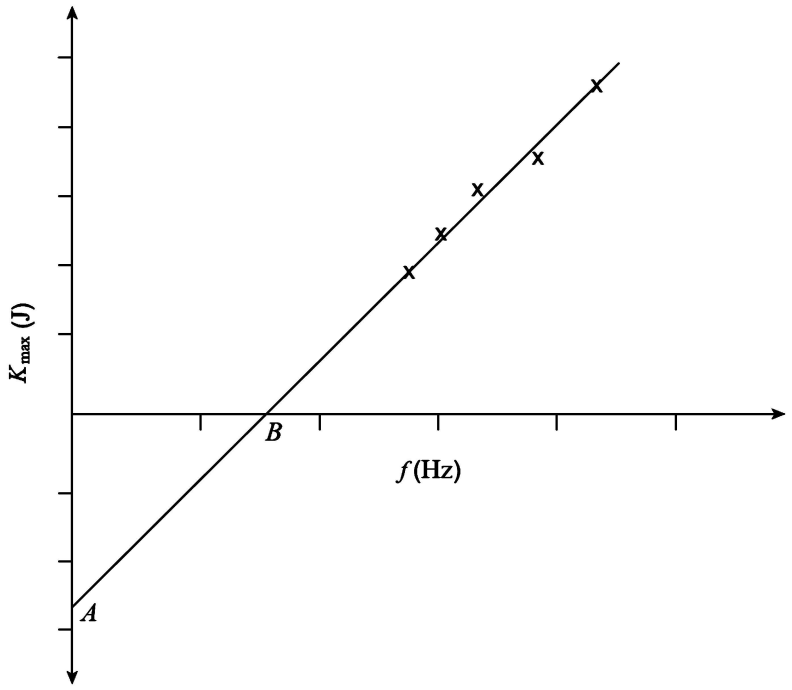
_____ (2)

7. In an experiment on the photoelectric effect the maximum kinetic energy K_{max} of the emitted electrons was measured for different frequencies f of light incident on a cathode. The graph below was drawn using the data that were collected:



(a) Identify the physical significance of A and B.

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_____ (2)

(b) Explain how a value for Planck's constant h can be obtained by relating the equation $K_{max} = hf - W$ to the graph above.

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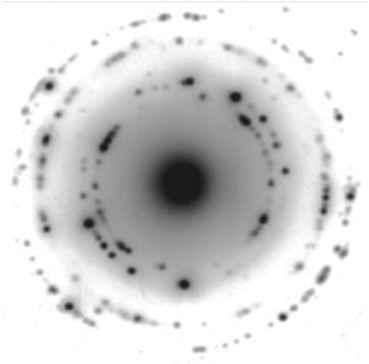
_____ (2)

8. The image below shows a pattern produced by diffraction of electrons from a crystal.



(a) Measuring the positions of parts of these patterns can be difficult because the image is blurry. Explain whether this is a source of random error or a source of systematic error.

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_____ (2)

(b) In one experiment involving electron diffraction, the electrons were accelerated to give them a kinetic energy of 100 eV.
Show that the momentum of one of these electrons is 5.40×10^{-24} $kgms^{-1}$.

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_____ (3)

(c) Hence calculate the angle of the first order maximum produced by diffraction of these electrons, given that there are 2.4 atoms/nm on the crystal surface used for diffraction.

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_____ (4)