Year 12 Physics - Module 7

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Contents

Chapter 1

Investigations

1.1 Investigation 1: Speed of Light Investigations

Summarise the historical and contemporary methods used to determine the speed of light and explain its current relationship to the measurement of time and distance.

1.2 Investigation 2: Spectral Analysis

Aim: To determine the emission spectra of various elements

Materials

- Spectroscope
- Spectral lamps with:
  - Hydrogen
  - Helium
  - Neon
  - Oxygen
  - Mercury
- Spectral lamp support
- Spectral lamp power supply

Risk Assessment

Hazard	**Precaution**
High voltage power pack	Turn off when not in use, do not touch contact points
Cuts from glass	Check spectral lamp before use, keep away from edge of table to prevent dropping
Burns from UV light	Don't observe directly, only view via spectrometer

Method

1. Prepare spectral support and power supply at 400V
2. Insert hydrogen spectral
3. Use spectrometer to observe emission spectrum and record wavelengths using chart on spectrometer
4. Repeat steps 2-3 with helium, neon, sulfur, and mercury
5. Record results

Results

Element	**Result**
Hydrogen	Bright pink
Helium	Red, orange, yellow
Neon	Red, orange
Oxygen	Pale blue white
Mercury	Blue-green

1.3 Investigation 3: Diffraction of Light

Summarise your qualitative analysis of light diffraction, including the experimental setup, observations, and what these phenomena demonstrate about the wave properties of light.

1.4 Investigation 4: Interference and Diffraction

Aim: To observe the diffraction and interference of light using diffraction gratings

Materials

- Laser pointer
- A diffraction grating set
- Meter ruler or tape measure

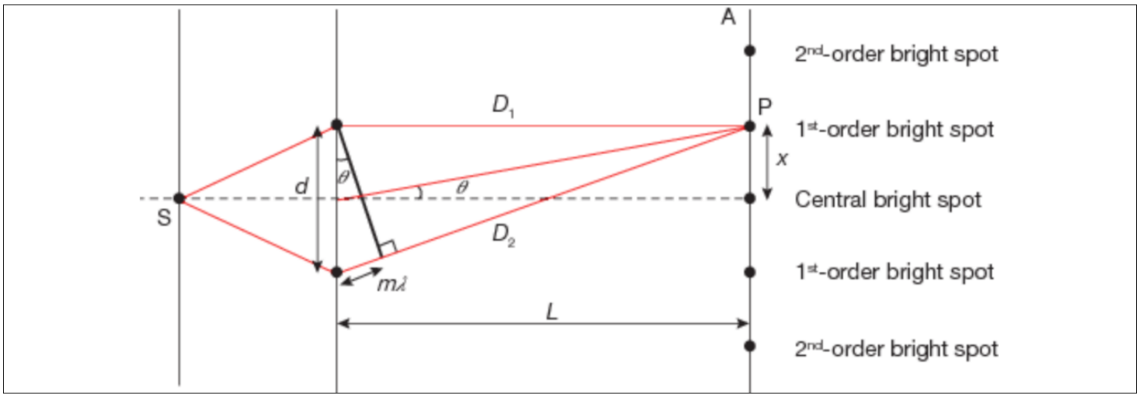
Risk Assessment

Hazard	Precaution
Retina burns	Do not directly look at laser light
Dropping equipment	Handle with caution, keep secure on table

Method

1. Use supports such as retort stands to set up the laser pointer so that it shines perpendicularly onto a screen, wall, or board at least one meter away.
2. Mount the diffraction grating directly in front of the laser pointer so that a regular row of dots appears on the screen.
3. Measure the values of x and L, and record these in your results table, along with the N value for your grating.
4. Repeat this procedure for each grating of different N value.
5. Analyse the data to determine the wavelength of the laser pointer.

Results



Slit separation d (m)	x (m)	L (m)	λ (m)	λ (nm)
100×10^{-6}	0.034	5.44	6.25×10^{-7}	625
200×10^{-6}	0.016	5.44	5.88×10^{-7}	588
300×10^{-6}	0.011	5.44	6.07×10^{-7}	607

Slit separation 1

$$
\begin{aligned}
\text{At very small angles, } \sin\theta &= \tan\theta \\
d\sin\theta &= m\lambda \\
\sin\theta &= \frac{m\lambda}{d} = \frac{x}{L} \\
\lambda &= \frac{dx}{L} \\
&= \frac{100\times10^{-6}\times0.034}{5.44} \\
&= 6.25\times10^{-7} \\
\text{Actual } \lambda \text{ of Ne-He laser} &= 6.328\times10^{-7}
\end{aligned}
$$

Slit separation 2

$$
\begin{aligned}
d\sin\theta &= m\lambda \\
\sin\theta &= \frac{m\lambda}{d} = \frac{x}{L} \\
\lambda &= \frac{dx}{L} \\
&= \frac{200\times10^{-6}\times0.016}{5.44} \\
&= 5.88\times10^{-7} \\
\text{Actual } \lambda \text{ of Ne-He laser} &= 6.328\times10^{-7}
\end{aligned}
$$

Slit separation 3

$$
\begin{aligned}
d\sin\theta &= m\lambda \\
\sin\theta &= \frac{m\lambda}{d} = \frac{x}{L} \\
\lambda &= \frac{dx}{L} \\
&= \frac{300\times10^{-6}\times0.011}{5.44} \\
&= 6.07\times10^{-7} \\
\text{Actual } \lambda \text{ of Ne-He laser} &= 6.328\times10^{-7}
\end{aligned}
$$

1.5 Investigation 5: Polarisation and Malus's Law

Aim: To observe plane polarisation of light using polarising filters, and to verify Malus' Law

Materials

- Torch
- Lux meter
- 2 polarising filters
- A protractor
- Retort stand
- Bosshead
- Clamp

Risk Assessment

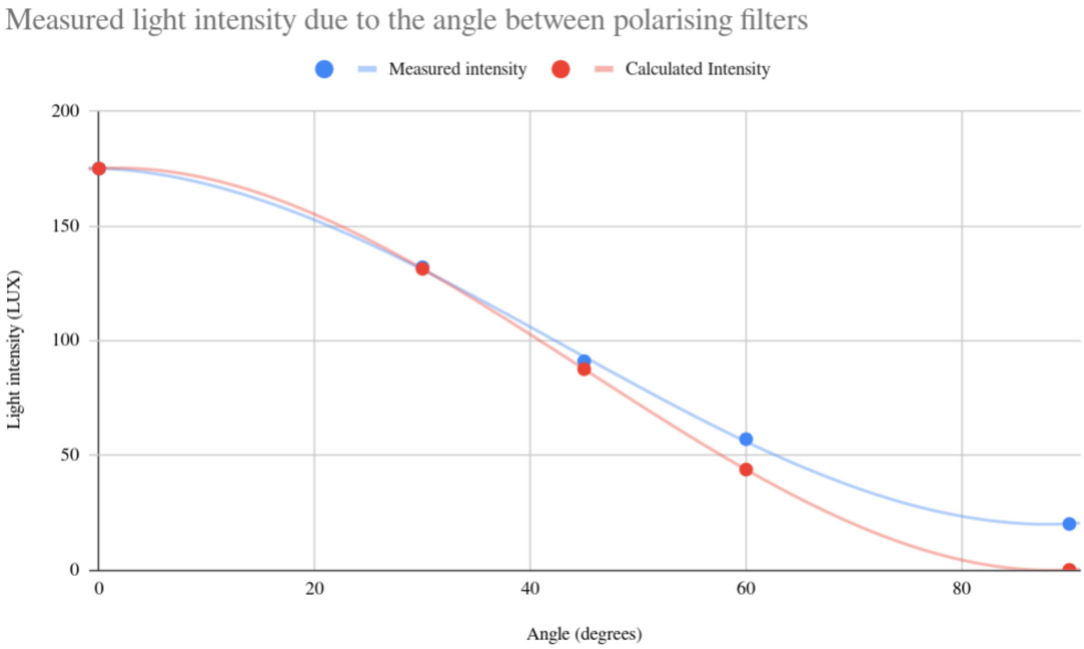
Hazard	Precaution
Eye damage from torch	Do not look directly at light source
Burning	Do not touch torch when in use. Allow cooling time when necessary

Method

1. Attach polarising filters to retort stand using bosshead
2. Attach torch above the polarising filters using bosshead and clamp facing down
3. Place lux meter below the polarising filter, lining up with the torch
4. Remove external light sources
5. Record the lux where the polarising filters have angles of 0, 30, 45, 60, 90 degrees.

Results

Angle between filters	Measured intensity	Calculated Intensity
0	175	175
30	132	131
45	91	87.5
60	57	43.8
90	20	0



Measured light intensity due to the angle between polarising filters
Measured intensity
Calculated Intensity
Light intensity (LUX)
Angle (degrees)
200
150
100
50
0
0
20
40
60
80

Chapter 2

Review Questions

2.1 Electromagnetic Spectrum

1. B
2. D
3. B
4. C
5. A
6. **Figure 8.11 shows the emission spectrum of sodium**
   (a) **Describe an experiment that could be used to examine the emission spectrum of an element.**
   The spectral lamp experiment can be used to observe the emission spectrum of an element. Running high voltage current through a spectral lamp containing a specific element will emit a bright spectrum that can be split into wavelengths by a prism or a spectrocope.
   (b) **Explain how emission spectra can be used to identify the elements in a sample?**
   A complete emission spectra can be analysed to find the lines in the black body spectrum and comparing that with the spectra of known elements.
   (c) **If sodium was present in the atmosphere of the Sun, how would it affect the emission spectra of the Sun?**
   If sodium is present, the Sun's emission spectrum will have lines at 589 nm to 590 nm.
7. **Outline one method that has been used to measure the speed of light**
   The speed of light light has been measured by Hertz who used an induction coil to produce a spark of a particular frequency. A spark gap was placed such that it would interact with the produced electromagnetic waves. By adjusting the position of the spark gap to maximise its intensity, the wavelength can be measured. Then, the formula $v = f\lambda$ can be used to determine the velocity of light.
8. **About half of the visible stars in the sky are binary star systems, which consist of two stars orbiting each other. Consider two stars of similar mass in a binary system that has its orbital plane almost parallel to the line of sight from the Earth. Each of the hydrogen atomic absorption lines in the stellar spectrum of the binary star system are observed to split into two lines of slightly different frequency and recombine to a single line every four days.**
   (a) **Explain why the motion of the stars would cause the atomic absorption lines in the stellar spectra to change in this way.**
   asdf

(b) **Determine the orbital period of this binary star system.**

(c) **Explain why some non-hydrogen absorption lines from the binary system move back and forth around a specific frequency periodically but do not split and recombine like the hydrogen lines.**