Tackling the examination

You have done all your revision and now you are in the examination room. This is your chance to show off your knowledge. Keep calm, take a few deep breaths, and try to remember all the things you have been told.

- Ensure you have read the rubric and you know how many questions to answer (on the AS and A2 physics papers it is easy – you must answer **all** the questions).
- Open your paper and read the first question carefully. Make sure you know what you are expected to do. Note the **command words** that are used.
- Do **not** start writing until you have carefully read the question, and re-read the subsection you are about to answer.
- When solving problems remember all the things you have been told about setting your work out: show your working, remember to convert to base units, and include units in your answers.

Now print out the question on the next two pages and try to answer it. Do not look at the sample answer until you have finished.

1 The Young modulus for structural steel is 200 GPa.

a Define **Young modulus**.

____

____

____ [1]

b To measure the Young modulus of structural steel, a sample is drawn into a wire of radius 0.48 mm. A length of wire of 1.25 m is used in the experiment.

i Calculate the tensile stress on the wire when a stretching force of 54.0 N is applied to it.

[2]

ii Calculate the extension of the wire.

[3]

iii Suggest and outline how the extension of the wire, in this experiment, could be measured.

____

____

____ [2]

The maximum stress this type of steel can withstand before breaking is 420 GPa.

c Calculate the maximum strain this steel can withstand.

[2]

Analysing your answers

Now look at the answers given by two students, and the comments from the examiner.

Student A

1 The Young modulus for structural steel is 200 GPa.

a Define **Young modulus.**

Young modulus is a measure of how much a material will stretch when a force is applied taking into account its length and its thickness. ✗ [1]

> The student has some idea but the answer is too vague. They have tried to explain what is meant by Young modulus but have got into a bit of a muddle. Compare this with the answer given by student B. (0/1)

b To measure the Young modulus of structural steel, a sample is drawn into a wire of radius 0.48 mm. A length of wire of 1.25 m is used in the experiment.

i Calculate the tensile stress on the wire when a stretching force of 54.0 N is applied to it.

$$\frac{54}{(\pi \times 0.482)} = 746\ \text{Pa}$$

✓ ✗ [2]

> From this jumble of numbers it appears that the student does seem to recognise that stress is force divided by area. However, they have totally ignored the fact that the radius is measured in millimetres, so that final answer should be in $N\ mm^{-2}$ not pascals. The student would score the first mark for knowing the formula for stress and attempting to substitute in the quantities. (1/2)

ii Calculate the extens ion of the wire.

$200 = \frac{7.46 \times x}{1.25}$ ✓ ✗ ✗

$= 0.56\,m$ [3]

Again there is no explanation of what is going on. It is possible to deduce that the student is aware of the formula. Again, they do not convert to base units, but this would not be penalised twice. The student then goes straight from this to the answer. Unfortunately they make a slip in their numbers, but as there is no evidence where they made the error, they lose both the next two marks. (1/3)

iii Suggest and outline how the extension of the wire, in this experiment, could be measured.

The increase is small so I would use a microscope. ✓ ✗ [2]

The student has recognised that the extension is small and come up with a solution, gaining the first mark. However they do not go on to explain how they would use the microscope. (1/2)

The maximum stress this type of steel can withstand before breaking is 420 MPa.

c Calculate the maximum strain this steel can withstand.

~~$\frac{420}{200} = 210$~~

$\frac{420 \text{ Mpa}}{200 \text{ GPa}} = 0.021$ ✓ ✓ [2]

It is good that his first attempt gave a silly answer – the wire stretching to 210 times its original length! This has prompted the student to think about consistency with units. Note that strain is pure ratio and has no units. (2/2)

Student B

1 The Young modulus for structural steel is 200 GPa.

a Define **Young modulus**.

Young modulus $= \dfrac{\text{stress}}{\text{strain}}$ ✔ [1]

This is a perfect answer. It is perfectly alright to give a definition in the form of an equation. (1/1)

b To measure the Young modulus of structural steel, a sample is drawn into a wire of radius 0.48 mm. A length of wire of 1.25 m is used in the experiment.

i Calculate the tensile stress on the wire when a stretching force of 54.0 N is applied to it.

stress $= \dfrac{\text{force}}{\text{area}}$ force = 54.0 N

radius = 0.48 mm = 0.48×10^{-3} m

$= \dfrac{54}{\pi} \times (0.48 \times 10^{-3})^2 = 746 \times 10^7$ Pa ✔ ✔ [2]

This is an excellent answer. The student has written down the equation that they need to use and then listed the quantities they need, ensuring that they have converted to base units. (2/2)

ii Calculate the extension of the wire.

$E = \dfrac{\text{stress}}{\text{strain}}$ $E = 200$ GPa $= 200 \times 10^9$ Pa length = 1.25 m

$200 \times 10^9 = \dfrac{746 \times 10^7 \times 1.25}{x}$ ✔

$x = \dfrac{746 \times 10^7 \times 1.25}{200 \times 10^9}$ ✔

$= 5.6 \times 10^{-4}$ m ✘ [3]

Another fine answer, although there is an arithmetic error in the final answer. However, it is clear that this is just a slip as the student shows a correct manipulation of the formula – so they will only lose one of the marks. The correct answer should have been 4.7×10^{-4} m. (2/3)

iii Suggest and outline how the extension of the wire, in this experiment, could be measured.

The extension is very small so the student would hang the wire from the ceiling and attach a vernier scale to it. He would hang a second wire next to it with a main scale. As he loaded the wire he could read off from the vernier. ✔ ✔ [2]

This is an alternative answer. Again, the student has recognised that the extension is very small and has come up with a good solution to the problem. They give an indication how they would use the apparatus and their explanation is sufficient to gain the second mark. It would be even better with a simple diagram. (2/2)

The more experience you have of doing practical work, the more easily you will be able to solve problems like this.

The maximum stress this type of steel can withstand before breaking is 420 MPa.

c Calculate the maximum strain this steel can withstand.

stress = 420 MPa = 420×10^6 Pa

$E = 200\text{ GPa} = 200 \times 10^9\text{ Pa}$

$E = \frac{\text{stress}}{\text{strain}}$

$\text{strain} = \frac{420 \times 10^6\text{ Pa}}{200 \times 10^9\text{ Pa}}$ ✔

= 0.021 ✔ [2]

Another perfect answer! (2/2)

Student A scored 5/10. This should be enough for a grade E, perhaps even a grade D.

Student B scored 9/10. An excellent effort. If this standard is maintained through the paper the student would certainly score an A*.

Now go through your answer to the question and see what you think you might have scored.

The lessons to learn from this exercise are:

- read the question properly taking note of any command words;
- show your working – under the pressure of examinations it is easy to make arithmetic slips;
- convert quantities to their base units to avoid errors with power of ten;
- learn definitions carefully.

Two more to try

Now try these two questions, but this time try and work to a time scale. There are 60 marks for Paper 2 and the time allowed to complete the paper is 60 minutes – about 1 minute per mark. The first of these questions is for 11 marks and the second is for 7 marks, so if you can complete the questions in under about 20 minutes you are on track to complete the paper.

2 Figure **1** shows the principles of an experiment a student set up to demonstrate interference of light.

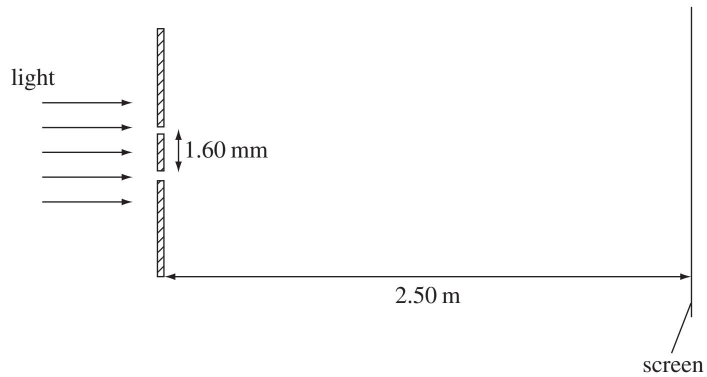


Figure 1

The light comes from a coherent, monochromatic source.

a **i** Explain what is meant by a **coherent** source of light.

____ [**1**]

ii Explain what is meant by a **monochromatic** source of light.

____ [**1**]

b On the screen a series of bright and dark fringes are seen. Explain how the fringes are formed.

____

____

____ [**3**]

c Figure **2** shows the fringes as seen on the screen.

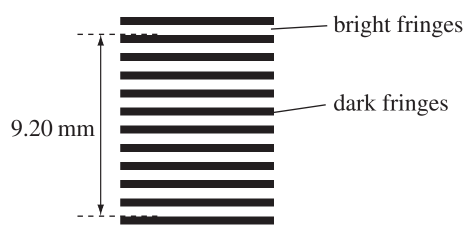


Figure 2

Calculate the wavelength of the light.

Wavelength = ________ m [3]

d The student now replaces the light source A with a white light source. State and explain how the pattern on the screen would change.

____

____

____

____ [3]

3 Figure 3 shows a potential divider circuit.

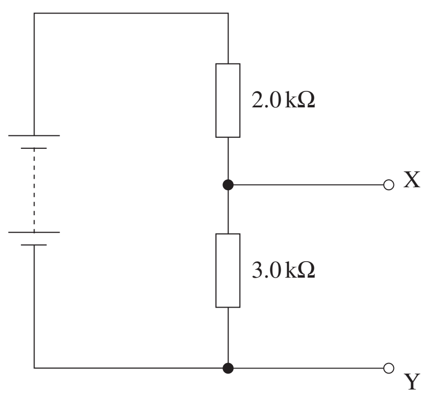


Figure 3

The battery has an e.m.f. of 6.0 V and its internal resistance is negligible.

a Explain what is meant by the term **e.m.f.**

____

____ [1]

b Show that the potential difference across the 3.0 kΩ resistor is 3.6 V.

[2]

c When a voltmeter is connected across XY it only reads 3.2 V.

i Suggest why the reading is less than the calculated value and deduce the resistance of the voltmeter.

____

____ [1]

ii Calculate the resistance of the voltmeter.

resistance = __________ kΩ [3]

Students' answers

Question 2

Student A

2 a i Explain what is meant by a **coherent** source of light.

Light of which is constant brightness ✗ [1]

The idea of coherence is not easy, but this student has not got any idea at all. (0/1)

ii Explain what is meant by a **monochromatic** source of light.

Light of a single colour ✗ [1]

The student has a bit more idea here, but this is really not enough for A level. We are looking for the idea of a single frequency or wavelength. (0/1)

b On the screen a series of bright and dark fringes are seen.
Explain how the fringes are formed.

The waves from the two are either in step or out of step causing them to

add up or subtract ✓ ✗ ✗ [3]

There is some idea here that it is phase differences between the waves from the two slits that produces interference, but the explanation is not linked to the dark and bright fringes that are observed. (1/3)

c Figure **2** shows the fringes as seen on the screen.
Calculate the wavelength of the light.

$$\lambda = \frac{1.6 \times 10^{-3} \times 9.2 \times 10^{-3}}{2.5}$$ ✗ ✗

$$= 5.888 \times 10^{-3}\,\text{m}$$ ✓ [3]

The student has forgotten that the 9.2 mm measures the distance across 10 fringes and has not included this in their answer. This is a serious mistake, betraying a lack of true understanding. One mark has been given as compensation because it is felt that the student displays some knowledge of the principle, and the rest of the calculation is good. (1/3)

d The student now replaces the light source A with a white light source.
State and explain how the pattern on the screen would change.

Coloured fringes will now be seen as white light is made up of different colours. ✓ ✗ ✗ [3]

The student recognises that coloured fringes will be seen, but the comment that white light is made up of colours does not really start to explain why coloured fringes are seen. We are looking for an understanding that the colours have different wavelengths, and therefore the maxima and minima of the colours are in different places. (1/3)

Student B

2 a i Explain what is meant by a **coherent** source of light.

Light which is all in phase with itself ✗ [1]

This almost gets there. The student recognises that there is something constant about the phase, but is unable to fully express this. We are looking for an answer where the student clearly explains that there is no (or a constant) phase difference across the whole wavefront. (0/1)

ii Explain what is meant by a **monochromatic** source of light.

Light of a single frequency ✓ [1]

Perfect! (1/1)

b On the screen a series of bright and dark fringes are seen.
Explain how the fringes are formed.

Waves from the two slits travel different distances, if the waves are in phase when they reach the screen there is a bright fringe, if they are exactly out of phase then a dark fringe is seen. ✓ ✓ ✓ [3]

An excellent answer. I particularly like the comment regarding the waves travel different distances from the two slits. (3/3)

c Figure **2** shows the fringes as seen on the screen.
Calculate the wavelength of the light.

$$\lambda = \frac{1.6 \times 10^{-3} \times 9.2}{10 \times 2.5}$$ ✗ ✓

$$= 5.89 \times 10^{-4}\,\text{m}$$ ✓ [3]

The student made a silly error, forgetting to change the 9.2 mm to metres. They got it right for the 1.6. Only one mark is lost, as this is clearly an arithmetic error rather than a lack of understanding. (2/3)

d The student now replaces the light source A with a white light source.
State and explain how the pattern on the screen would change.

Coloured fringes will now be seen as the different colours have different wavelengths and will interfere in different places. ✓ ✓ ✗ [3]

The student recognises that coloured fringes will be seen and that the different colours have different wavelengths. However, the final step in the argument is missing – that the maxima/minima are in different places because the longer the wavelength, the greater the path difference required for the waves to get exactly (180°) out of step. (2/3)

Question 3

Student A

3 **a** Explain what is meant by the term **e.m.f.**

The voltage across the terminals when there is no current flowing. ✗ [1]

Although this is sometimes accepted at lower levels it is not enough at A level, where an explanation in terms of the work done in the complete circuit is needed. (0/1)

b Show that the potential difference across the 3.0 kΩ resistor is 3.6 V.

The current = $\frac{6.0}{5.0}$ = 1.2 A

Potential difference = 3.0 × 1.2 ✓ ✗ [2]

The student has gone through the correct process, but has not recognised that the resistors have a resistance in the kilohm range, so the current is not 1.2 A, but 1.2 mA. Also, the student has not completed the final calculation. (1/2)

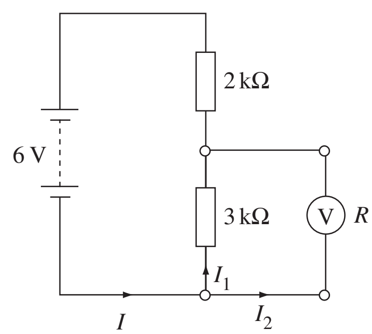
c When a voltmeter is connected across XY it only reads 3.2 V.

i Suggest why the reading is less than the calculated value and deduce the resistance of the voltmeter.

Because the voltmeter has resistance so a current passes through it changing the total resistance in the circuit ✓ [1]

The student recognises that the fall in potential is to do with the resistance of the voltmeter; their explanation is rather muddled but there is just enough to gain the mark. (1/1)

ii Calculate the resistance of the voltmeter.



$I = I_1 + I_2$

$1.2 = I_1 + I_2$

$6 = 3I_1 + 2 \times 1.2$

$I_1 = 1.2\ \text{A}$

$I_2 = 0$ [3]

The student starts off sensibly by drawing out the circuit and labelling the currents and resistances. However, they make the basic mistake of assuming that the current through the 2 kΩ resistor is still 1.2 mA, with the inevitable result that the current through the 3 kΩ resistor is also 1.2 mA and the current through the voltmeter is zero. To sort this out they really need to use Kirchhoff's laws. (0/3)

Student B

3 a Explain what is meant by the term **e.m.f.**

The total work done in the circuit by each coulomb of electricity. This includes the work done in driving the current through the battery itself. [1]

An excellent answer. The second sentence is not really needed, but it shows that the student really understands the concept. (1/1)

b Show that the potential difference across the 3.0 kΩ resistor is 3.6 V.

The current = 6.0/5.0 k = 1.2 mA

Potential difference = 3.0 kΩ × 1.2 mA = 3.6 V [2]

Once more a perfect answer. (2/2)

c When a voltmeter is connected across XY it only reads 3.2 V.

i Suggest why the reading is less than the calculated value and deduce the resistance of the voltmeter.

Because the voltmeter has resistance so the resistance in the lower arm of the circuit is now the combined resistance of the 3 kΩ resistor and the voltmeter. ✓ [1]

The student recognises that the fall in potential is to do with the resistance of the voltmeter. This explanation is of a high standard. (1/1)

ii Calculate the resistance of the voltmeter

$I = I_1 + I_2$

In the loop containing the two resistors:

$6 = 3.2 + 2I$

$I = \frac{2.8}{2} = 1.4\text{ A}$ ✓

potential drop across 3 k resistor = 6 − 2.8 = 3.2 V

so current = $\frac{3.2}{3} = 1.67\text{ A}$ ✗

arithmetic error

so $I_2 = 1.4 - 1.67 = 0.27\text{ A}$

So resistance of voltmeter = $\frac{3.2}{2.7} = 1.19\text{ k}\Omega$ ✓ [3]

error carried forward

The student starts off sensibly by drawing out the circuit and labelling the currents and resistances. They correctly calculate the current through the 2 kΩ resistor. They go on to find the current through the 3 kΩ resistor, but then the student makes an arithmetic error (It should have been 1.067 A.) The student then uses the incorrect answer correctly (apart from losing a minus sign!) to find the voltmeter's resistance. The correct final answer should have been 9.6 kΩ. (2/3)

Summary of students' performance

In question 2 student A scores 3/11 and in question 3 only 2/7. This sort of level is below that of a grade E. Taken with question 1, student A might just scrape an E.

Student B, however, scores 8/11 and 6/7, an excellent performance keeping well on track for an A grade.

Conclusion

These examples should help you see what the examiners are looking for and should demonstrate some of the common mistakes that are made. You need to learn your work thoroughly, but also you must learn to **understand**.