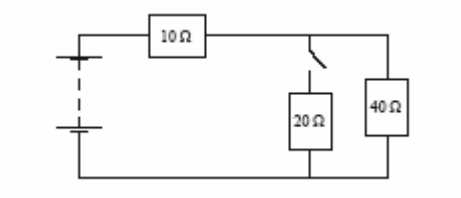
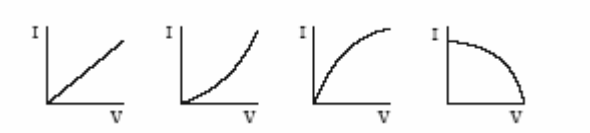
## Unit 2: Physics at Work

| Question Number | Question | |
|---|---|---|
| **1** | Three identical resistors are connected across a potential difference *V* so that one of them is in parallel with the other two which are connected in series. The power dissipated through the first one, compared to the power dissipated by each of the other two, is approximately | |
| | Answer | Mark |
| | D | **1** |

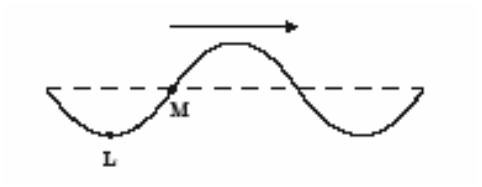
| Question Number | Question | |
|---|---|---|
| **2** | A circuit is set up as shown in the diagram.<br>  <br><br>When the switch is closed, the potential difference across the 20 Ω resistor would | |
| | Answer | Mark |
| | C | **1** |

| Question Number | Question | |
|---|---|---|
| **3** | How much electrical energy is required to move 4.00 mC of charge through a potential difference of 36.0 V? | |
| | Answer | Mark |
| | B | **1** |

| Question Number | Question | |
|---|---|---|
| **4** | A source of light emits a train of waves lasting 0.04 μs. The light has a wavelength of 600 nm and the speed of light is $3 \times 10^8$ m $s^{-1}$. How many complete waves are sent out? | |
| | Answer | Mark |
| | A | **1** |

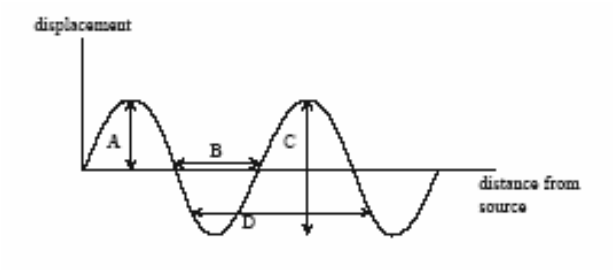
| Question Number | Question | |
|---|---|---|
| **5** | Which of the following graphs gives the current-potential difference characteristic of an NTC thermistor.<br>  | |
| | Answer | Mark |
| | B | **1** |

| Question Number | Question | |
|---|---|---|
| **6** | Which of the following statements about standing waves is true? | |
| | Answer | Mark |
| | C | **1** |

| Question Number | Question | |
|---|---|---|
| **7** | The diagram shows a wave on a rope. The wave is travelling from left to right.<br>  <br>At the instant shown, point **L** is at a maximum displacement and point **M** has zero displacement. Which row in the table correctly describes the motion of points **L** and **M** during the next half cycle of the wave? | |
| | Answer | Mark |
| | B | **1** |

| Question Number | Question | |
|---|---|---|
| **8** | Electromagnetic waves are produced by oscillating charges. Sound waves are produced by oscillating tuning forks. How are these waves similar? | |
| | Answer | Mark |
| | C | **1** |

| Question Number | Question | |
|---|---|---|
| **9** | Two points on a progressive wave differ in phase by $\frac{\pi}{4}$ radian. The distance between them is 0.50 m. The frequency of the oscillations is 10 Hz. The maximum speed of the wave is | |
| | Answer | Mark |
| | D | **1** |

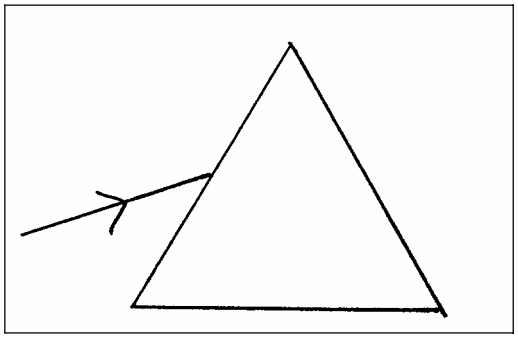
| Question Number | Question | |
|---|---|---|
| **10 (a)** | A loudspeaker emits a sound wave of wavelength of 0.66 m. The diagram shows how displacement varies with distance from the loudspeaker at one instant of time.<br>  <br><br>Which letter indicates the wavelength of the sound wave? | |
| | Answer | Mark |
| | D | **1** |

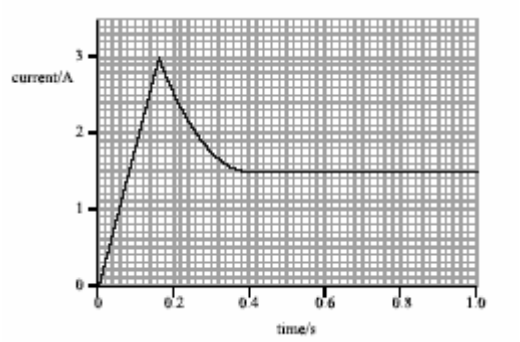
| Question Number | Question | |
|---|---|---|
| **10(b)** | Sound travels at 330 m $s^{-1}$ in air. Calculate the period of the wave.<br>Period = | |
| | | |
| | **Wavelength**<br><br>Use of $v = f\lambda$ (1)<br>Use of $f = 1/T$ (1)<br>Answer $T$ = [0.002 s] (1)<br>[give full credit for candidates who do this in 1 stage $T = \lambda/v$]<br>Example of answer<br>$v = f\lambda$<br>$f$ = 330 / 0.66<br>$T = 1/f$ = 0.66 / 330<br>$T$ = 0. 002 s | **3** |

| Question Number | Question | |
|---|---|---|
| **11** | State **two** conditions necessary for total internal reflection to occur at an interface between air and water.<br>Condition 1<br>Condition 2 | |
| | Answer | Mark |
| | Direction of travel of light is water → air (1)<br>Angle of incidence is greater than the critical angle (1) | **2** |

| Question Number | Question | |
|---|---|---|
| **12(a)** | Explain with the aid of diagrams why transverse waves can be polarised but longitudinal ones cannot be polarized. | |
| | Answer | Mark |
| | Transverse waves oscillate in any direction perpendicular to wave direction<br>Longitudinal waves oscillate in one direction only OR parallel to wave direction.<br>Polarisation reduces wave intensity by limiting oscillations and wave direction to only one plane OR limiting oscillations to one direction only.<br>( accept vibrations and answers in terms of an example such as a rope passing through slits) | **1**<br>**1**<br><br>**1** |

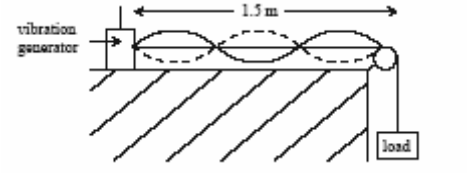
| Question Number | Question | |
|---|---|---|
| **12(b)** | Describe with the aid of a diagram how you could demonstrate that light can be polarised. | |
| | Answer | Mark |
| | Light source, 2 pieces of polaroid and detector e.g. eye, screen, LED OR laser, 1 polaroid and detector<br>Rotate one polaroid<br>Intensity of light varies | **1**<br><br>**1**<br>**1** |

| Question Number | Question | |
|---|---|---|
| **13** | A ray of light travelling, in air, strikes the middle of one face of an equilateral glass prism as shown.<br>  <br>State what happens to the following properties as the light goes from the air into the glass.<br>• Frequency<br>• Wavelength<br>• Speed | |
| | Answer | Mark |
| | Frequency unaltered (1)<br>Wavelength decreases (1)<br>Speed decreases (1) | **3** |

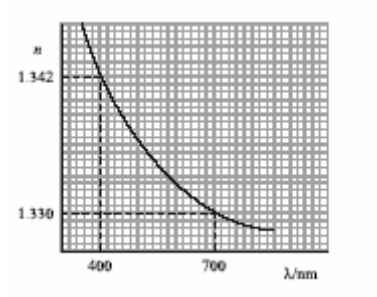
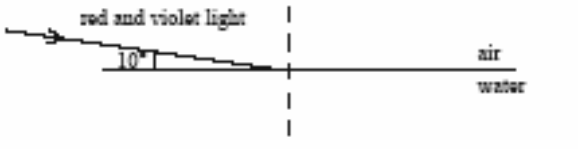
| Question Number | Question | |
|---|---|---|
| **14(a)** | The graph shows how the current in a 9V filament lamp varies during one second after it has been turned on.<br>  <br><br>A student wishes to carry out an experiment to verify these results. Explain why using a sensor and computer is a sensible option and suggest a suitable sampling rate. | |
| | Answer | Mark |
| | **Use of sensor**<br>Event happens very quickly OR cannot take readings fast enough<br>Sampling rate: 50+ samples per second | <br>**1**<br>**1** |

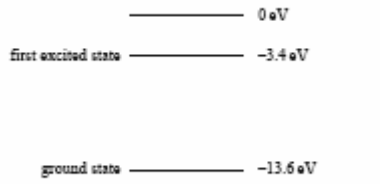
| Question Number | Question | |
|---|---|---|
| **14(b)** | Explain the shape of the graph and why the filament is more likely to fail when being switched on rather than at other times. | |
| | Answer | Mark |
| | Initially the temperature is low so current is high<br>Resistance of filament increases as temperature increases<br>Current falls to steady value when temperature is constant<br>Maximum heating is when lamp is switched on / when current is highest<br>Filament breaks due to melting caused by temperature rise | **Max 4** |

| Question Number | Question | |
|---|---|---|
| **15** | About 100 years ago X-rays were first used in hospitals. At that time, many of the doctors who worked with X-rays died young. Explain why this occurred and the implications it has for the use of new technology today. | |
| | Answer | Mark |
| **QWC(i, iii)** | The answer must be clear and the answer must be organised in a logical sequence<br>• It was known that X penetrated (1)<br>• It was not known that X rays were harmful (1)<br>• Doctors died because of too much exposure (1)<br>• Lack of shielding (1)<br>• New treatments may have unknown side effects (1)<br>• Treatments need to be tested / time allowed for side effects to appear (1) | **Max 4** |

| Question Number | Question | |
|---|---|---|
| **16** | The following apparatus is set up. When the frequency of the vibrator is 60 Hz, the standing wave shown in the diagram is produced.<br>  <br><br>What is the wavelength of this standing wave?<br>Wavelength = …… | |
| | Answer | Mark |
| | [1.0 m] (1) | 1 |

| Question Number | Question | |
|---|---|---|
| **16(b)** | The frequency of the vibrator is altered until the standing wave has 2 more nodes. Calculate the new frequency.<br>Frequency = | |
| | Answer | Mark |
| | Ratio of (5 or 6 / 3 ) × 60 (1)<br>Answer [$f$ = 100 Hz] (1) | **2** |

| Question Number | Question | |
|---|---|---|
| **17** | The graph shows how the refractive index of water, *n* varies with wavelength λ of the light in a vacuum. The values for red and violet light are indicated.<br>  <br><br>The diagram shows a mixture of red and violet light incident on an air/ water interface.<br>  <br><br>Calculate the angle of refraction for the red light.<br>Angle of refraction =...<br><br>On the diagram draw the approximate paths of the refracted rays. | |
| | Answer | Mark |
| | Use of sin i / sin r = μ (1)<br>Use of either 80° or 1.33 (1)<br>[r = 48° ] (1)<br><br><u>Example of answer</u><br>sin 80 / sin r = 1.33<br>[r = 48°]<br><br>Both rays refracted towards the normal<br>Violet refracted more than red | **3**<br><br><br><br><br><br>**2** |

| Question Number | Question | |
|---|---|---|
| **18(a)** | Below is a simplified energy level diagram for atomic hydrogen.<br>  <br><br>A free electron with 12 eV of kinetic energy collides with an atom of hydrogen. As a result the atom is raised to its first excited state. Calculate the kinetic energy of the free electron, in eV, after the collision.<br>Kinetic energy = eV | |
| | Answer | Mark |
| | Calculation of energy required by atom (1)<br>Answer [1.8 (eV)] (1)<br>Example of answer:<br>Energy gained by atom = 13.6 eV – 3.4 eV = 10.2 eV<br>KE of electron after collision = 12 eV – 10.2 eV = 1.8 eV | **2** |

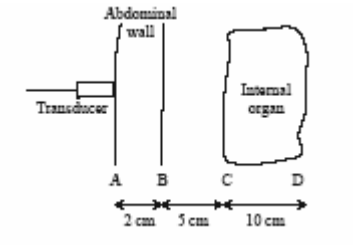
| Question Number | Question | |
|---|---|---|
| **18(b)** | Calculate the wavelength of the photon emitted when the atom returns to its ground state.<br>Wavelength = | |
| | Answer | Mark |
| | Use of $E = hf$ and $c = f\lambda$ (1)<br>Conversion of eV to Joules (1)<br>Answer = [$1.22 \times 10^{-7}$ m] (1)<br>Example of answer<br>$E = hf$ and $c = f\lambda$ $E = hc/\lambda$<br>$\lambda = (6.63 \times 10^{-34}\ \text{J s} \times 3 \times 10^{8}\ \text{m s}^{-2}) \div (10.2\ \text{eV} \times 1.6 \times 10^{-19}\text{C})$<br>$\lambda = 1.21 \times 10^{-7}$ m | **3** |

| Question Number | Question | |
|---|---|---|
| **19** | A group of students is discussing why the resistance of the metal filament of a lamp and the resistance of an NTC thermistor respond differently to changesin temperature.<br><br>One student says that the increased vibrations of the atoms affect the conduction process. Another student says that as the temperature increases more electrons can break free of the atoms and take part in conduction.<br><br>Both students are correct. Explain how these **two** effects apply to the lamp and the thermistor. | |
| | Answer | Mark |
| **QWC(i-iii)** | The answer must be clear, use an appropriate style and be organised in a logical sequence.<br>Reference to $I = nqvA$ (1)<br><br>**For the lamp**<br>Increased atomic vibrations reduce the movement of electrons (1)<br>Resistance of lamp increases with temperature (1)<br><br>**For the thermistor**<br>Increased atomic vibrations again reduce movement of electrons (1)<br>But increase in temperature leads to a large increase in n (1)<br>Overall the resistance of the thermistor decreased with increase in temperature. (1) | **Max 5** |

| Question Number | Question | |
|---|---|---|
| **20(a)** | What is meant by diffraction? | |
| | Answer | Mark |
| | Diffraction is the change in direction of wave or shape or wavefront (1)<br>when the wave passes an obstacle or gap (1) | **2** |

| Question Number | Question | |
|---|---|---|
| **20(b)** | How did considering light as photons enable scientists to explain why electrons could be emitted instantly from a metal surface? | |
| | Answer | Mark |
| | The energy of the wave is concentrated into a photon (1)<br>One photon gives all its energy to one electron (1) | **2** |

| Question Number | Question | |
|---|---|---|
| **20(c)** | Explain why this effect only happens when the light is above a certain frequency. | |
| | Answer | Mark |
| | Energy of photon increases as frequency increases OR reference to $E = hf$ (1)<br>Electrons require a certain amount of energy to break free and this corresponds to a minimum frequency (1) | **2** |

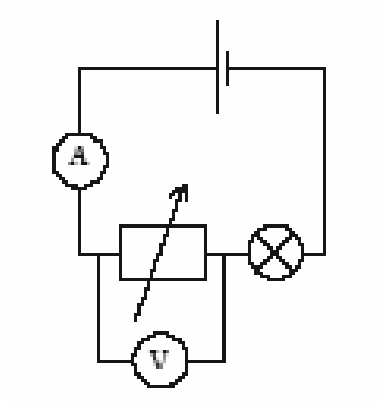
| Question Number | Question | |
|---|---|---|
| **21(a)(i)** | Ultrasound images of the body are a useful diagnostic tool for doctors. A single transducer can be used both to send and receive pulses of ultrasound.<br><br>The diagram shows a lateral cross-section through part of the abdomen. The diagram is not to scale.<br><br>  <br><br><br>Calculate the time interval between sending out a single pulse and receiving its echo from interface B. The speed of ultrasound in the abdominal wall is 1500 m $s^{-1}$.<br><br>Time interval = | |
| | Answer | Mark |
| | Use of speed = distance over time (1)<br>Distance = 4 cm (1)<br>Answer = [2.7 × $10^{-5}$ s] (1)<br>Example of answer<br>t = 4 cm ÷ 1500 m $s^{-1}$<br>t = 2.7 × $10^{-5}$ s | **3** |

| Question Number | Question | |
|---|---|---|
| **21(a)(ii)** | The time between pulses being emitted by the transducer is 200 μs. At what frequency are the pulses emitted? | |
| | Answer | Mark |
| | Use of $f = 1/T$ (1)<br>Answer = [5000 Hz] (1) | **2** |

| Question Number | Question | |
|---|---|---|
| **21(a)(iii)** | The time interval before the echo returns from interface D is 250 μs. Suggest why this time interval will make reflections from D difficult to interpret and what could be done to overcome this problem. | |
| | Answer | Mark |
| | Time for pulse to return greater than pulse interval (1)<br>All reflections need to reach transducer before next pulse sent. (1)<br>Will result in an inaccurate image. (1) (Max 2)<br>Need to decrease the frequency of the ultrasound. (1) (Max 3) | **Max 3** |

| Question Number | Question | |
|---|---|---|
| **21(a)(iv)** | State one reason why ultrasound rather than X-rays is now used to scan expectant mothers. | |
| | Answer | Mark |
| | X-rays damage cells/ tissue/ foetus/ baby but ultrasound does not (need reference to both X-rays and ultrasound) (1) | **1** |

| Question Number | Question | |
|---|---|---|
| **21(b)** | Ultrasound is also used to measure blood flow in the body. It uses the Doppler shift of the reflected pulse to measure the speed of blood through the arteries of the body.<br><br>Describe the principle of this method and how it can be used to determine the speed of blood. You may be awarded a mark for the clarity of your answer. | |
| | Answer | Mark |
| **QWC(i-iii)** | The answer must be clear, use an appropriate style and be organised in a logical sequence<br><br>Doppler shift is the change in frequency of a wave when the source or the receiver is moving (1)<br>Requirement for a continuous set of waves (1)<br>Two transducers required (one to transmit and one to receive) (1)<br>Change in frequency is directly related to the speed of the blood (1) | **4** |

| Question Number | Question | |
|---|---|---|
| **22(a)** | A student sets up the following circuit to measure the internal resistance of a cell.<br>  <br><br>What is wrong with his circuit diagram? | |
| | Answer | Mark |
| | Voltmeter is across resistor should be across cell (1) | **1** |

| Question Number | Question | |
|---|---|---|
| **22(b)** | Using the correct circuit the student obtains the following results.<br><br>Current in the cell *I* / A: 0.5, 0.9, 1.5, 1.9, 2.5, 2.9<br>Terminal potential difference across the cell *V* / V: 1.2, 1.0, 0.8, 0.6, 0.4, 0.2<br><br>On the grid below, plot these results and draw the line of best fit through your points. | |
| | Answer | Mark |
| **22(b)(i)** | **Plot of graph**<br>Check any three points (award mark if these are correct) (3)<br>Line of best fit | **3** |
| Question Number | Question | |
| **22(b)(ii)** | Use your graph to determine the e.m.f. of the cell.<br>e.m.f. = ..... | |
| | Answer | Mark |
| | e.m.f. = [1.36 – 1.44 V] (1) | **1** |

| Question Number | Question | |
|---|---|---|
| **22(b)(iii)** | Use your graph to determine the internal resistance of the cell.<br>Internal resistance = | |
| | Answer | Mark |
| | Attempt to find gradient (1)<br>Answer [0.38 – 0.42 Ω] (1) | **2** |

| Question Number | Question | |
|---|---|---|
| **22(c)** | The experiment is repeated with two such cells connected in series. How does the graph differ? | |
| | Answer | Mark |
| | Intercept would twice value above (1) (accept numerical value 2× value (b)(ii))<br>Gradient would be twice value above (1) (accept numerical value 2× value (b)(iii)) | **2** |