FOR OFFICIAL USE

3220/401

NATIONAL QUALIFICATIONS 2009

TUESDAY, 26 MAY
9.00 AM – 10.30 AM

PHYSICS
STANDARD GRADE
General Level

Fill in these boxes and read what is printed below.

Full name of centre

Town

Forename(s)

Surname

Date of birth
   Day  Month  Year

Scottish candidate number

Number of seat

Reference may be made to the Physics Data Booklet.

1 All questions should be answered.

2 The questions may be answered in any order but all answers must be written clearly and
   legibly in this book.

3 For questions 1–6, write down, in the space provided, the letter corresponding to the
   answer you think is correct. There is only one correct answer.

4 For questions 7–20, write your answer where indicated by the question or in the space
   provided after the question.

5 If you change your mind about your answer you may score it out and replace it in the
   space provided at the end of the answer book.

6 If you use the additional space at the end of the answer book for answering any questions,
   you must write the correct question number beside each answer.

7 Before leaving the examination room you must give this book to the invigilator. If you do
   not, you may lose all the marks for this paper.

Use blue or black ink. Pencil may be used for graphs and diagrams only.
1. What is the frequency of a wave, if 20 crests pass a point in two seconds?
   A  0.1 hertz
   B  2 hertz
   C  10 hertz
   D  20 hertz
   E  40 hertz

   Answer

2. How long does a geostationary satellite take to orbit the Earth?
   A  1 hour
   B  1 day
   C  1 week
   D  1 month
   E  1 year

   Answer

3. Which of the following will **not allow** the transmission of sound waves?
   A  Brick
   B  Vacuum
   C  Water
   D  Air
   E  Wood

   Answer

4. Which of the following statements is **always** true about the structure of the atom?
   A  It has more electrons than protons.
   B  It has more protons than neutrons.
   C  It has an equal number of protons and electrons.
   D  It has more neutrons than protons.
   E  It has an equal number of neutrons and electrons.

   Answer
5. Which of the following is a digital output device?
   A  Solenoid
   B  Loudspeaker
   C  Motor
   D  Lamp
   E  Microphone

   Answer □ 1

6. In which of the following would a voltage **not** be induced in a coil of wire?
   A  Rotating the coil of wire near to a magnet
   B  Rotating a magnet near to the coil of wire
   C  Holding a magnet stationary within the coil of wire
   D  Moving a magnet in and out of the coil of wire
   E  Moving the coil of wire between the poles of a magnet

   Answer □ 1

[Turn over]
7. A student listens to his radio using headphones.

(a) State the main energy transformation that takes place in the headphones.

.................................................................................................................................

The table shows the frequencies for different radio stations.

<table>
<thead>
<tr>
<th>Radio Station</th>
<th>Frequency (mega hertz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forth 1</td>
<td>97.3</td>
</tr>
<tr>
<td>Real Radio</td>
<td>101.0</td>
</tr>
<tr>
<td>Radio Borders</td>
<td>103.1</td>
</tr>
<tr>
<td>Isles</td>
<td>103.0</td>
</tr>
<tr>
<td>Central Scotland FM</td>
<td>103.1</td>
</tr>
<tr>
<td>Radio Scotland</td>
<td>95.0</td>
</tr>
</tbody>
</table>

(b) Explain why the radio stations Radio Borders and Central Scotland FM are allowed to transmit at the same frequency.

.................................................................................................................................
7. (continued)

(c) The block diagram shows some of the main parts of a radio receiver.

![Block Diagram]

(i) Complete the block diagram by filling in the missing labels.

(ii) What is the purpose of the tuner?

......................................................................................................................................................... 1

[Turn over
8. An experiment is set up to investigate sound waves. A signal generator is connected to a loudspeaker. The signal generator has a frequency control and an amplitude control.

(a) Complete the sentence below by circling the correct answer.

The \( \boxed{\text{amplitude}} \) control is used to adjust the loudness of the sound wave. 1

(b) The controls of the signal generator are set up to produce a sound wave from the loudspeaker. An oscilloscope is now connected across the loudspeaker. The oscilloscope trace is shown in Figure 1. Complete Figure 2 to show the trace obtained when the frequency is \textbf{doubled}, but the amplitude remains unchanged. The oscilloscope controls are unchanged.

![Figure 1](image1)

![Figure 2](image2)
9. A design engineer uses three ammeters to measure the current, in amperes, at various points in the circuit of a model-sized electrical fan heater.

(a) Calculate the reading on ammeter 1.

Space for working and answer

(b) What happens to the reading on ammeter 1 when switch S is opened?

(c) The full size mains fan heater has a rating plate for UK supply stating its operating voltage and frequency.

Complete parts (i) and (ii) below by circling the correct answers.

(i) The voltage is \( \frac{110}{230} \) volts \( \frac{a.c.}{d.c.} \).

(ii) The mains frequency is \( \frac{50}{60} \) hertz.
10. Party lights consist of 16 identical light bulbs connected in series. They operate from a 24 volt power supply. The current in the circuit is 1.25 amperes.

(a) Calculate the total resistance of the bulbs in the circuit.

Space for working and answer

(b) Calculate the voltage across each light bulb.

Space for working and answer

(c) A fault occurs in the circuit and a continuity tester is needed to find the fault. The circuit diagram for the continuity tester is shown.

(i) Describe how the continuity tester could be tested to make sure that it is working.

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(ii) The continuity tester is found to be faulty. State one possible reason why it is not working.

.................................................................................................................................
10. (continued)

(d) Conventional filament lamps are now being replaced by discharge tubes.

(i) State where the energy transformation occurs in:

(A) the filament lamp;

.......................................................................................................................... 1

(B) the discharge tube.

.......................................................................................................................... 1

(ii) State why discharge tubes are replacing conventional filament lamps.

.......................................................................................................................... 1

[Turn over
11. The electromagnetic spectrum is shown below.

<table>
<thead>
<tr>
<th>radio &amp; tv</th>
<th>microwaves</th>
<th>infrared</th>
<th>visible light</th>
<th>ultraviolet</th>
<th>X-rays</th>
<th>gamma rays</th>
</tr>
</thead>
</table>

Different types of waves in the spectrum are used in medicine.

(a) What property do all electromagnetic waves have in common?

........................................................................................................................................ 1

(b) Describe one use of X-rays in medicine.

........................................................................................................................................ 1

(c) Gamma radiation is used in medicine as a tracer.

A tracer is a radioactive substance injected into the body.

The gamma radiation then given off from the body is monitored.

(i) Explain why gamma radiation is used rather than alpha or beta radiation.

........................................................................................................................................ 1

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(ii) What is the unit for the activity of the gamma radiation?

........................................................................................................................................ 1

(d) Light can be produced by lasers.

Describe the use of the laser in one application of medicine.

........................................................................................................................................ 1
11. (continued)

(e) A student sets up the following experiment to compare how two different brands of sunglasses protect from ultraviolet radiation.

The student uses beads which change colour when exposed to ultraviolet radiation.

The student covers one set of beads with a lens from brand A and another with a lens from brand B.

The ultraviolet lamp is switched on for 30 minutes.

The apparatus is set up as shown.

(i) Give one reason why this test is not a fair one.

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(ii) Why can exposure to ultraviolet radiation be harmful to humans?

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1

1

[Turn over
12. An orchestra uses many different musical instruments.

The table lists the lowest and highest sound frequencies for some of these instruments.

<table>
<thead>
<tr>
<th>Musical Instrument</th>
<th>Lowest Frequency (hertz)</th>
<th>Highest Frequency (hertz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acoustic Guitar</td>
<td>73</td>
<td>1174</td>
</tr>
<tr>
<td>Piano</td>
<td>28</td>
<td>4186</td>
</tr>
<tr>
<td>Flute</td>
<td>261</td>
<td>2637</td>
</tr>
<tr>
<td>Trumpet</td>
<td>165</td>
<td>1046</td>
</tr>
<tr>
<td>Violin</td>
<td>196</td>
<td>3520</td>
</tr>
<tr>
<td>Cello</td>
<td>65</td>
<td>660</td>
</tr>
<tr>
<td>Piccolo</td>
<td>523</td>
<td>4000</td>
</tr>
</tbody>
</table>

(a) (i) Which instrument in the table produces the longest wavelength?

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(ii) Calculate the wavelength for the lowest frequency of a piccolo.

(The speed of sound in air is 340 metres per second.)

Space for working and answer

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(b) During one concert performance the sound level was measured.

State the unit of sound level measurement.

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[3220/401]
13. A radio controlled model fire engine receives signals from a control unit. One of the control functions operates a siren on the fire engine.

(a) State a suitable output device for the siren.

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(b) The fire engine contains an electronic system to control the siren.

The signals at various parts of the system are displayed on oscilloscope screens.

(i) Which screen shows a digital signal?

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(ii) The signal shown on screen 2 is now amplified.

The oscilloscope settings are unchanged.

Draw the amplified signal in the box below.

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........................................................................................................................................
14. A pedestrian crossing at a set of traffic lights has an electronic control system to operate the “green man” light. Part of the system is shown.

![Diagram of pedestrian crossing system]

Input A is from the traffic lights and gives a logic 1 when the red light only is on, and a logic 0 at other times.

Input B is operated by pedestrians when they want to cross.

(a) State a suitable input device to be used by the pedestrians to activate the “green man” light.

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(b) The “green man” light comes on when the red traffic light, only, is on and the crossing is operated by a pedestrian. What type of logic gate should be used at position X?

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(c) The “green man” light consists of a number of LEDs.

(i) Draw the symbol for an LED.

Space for symbol

......................................................................................................

(ii) Why does each LED need a series resistor?

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1
14. **(continued)**

\[(d)\] The “green man” light has to stay on long enough for the pedestrian to cross.

This crossing has a display to show pedestrians the number of seconds the “green man” light will remain on.

State an output device that could be used to display this time.

.......................................................... .......................................................... .......................................................... 1

[Turn over
15. An indoor kart track hosts a racing competition.

(a) Describe how to find the average speed of a kart for one complete lap of the track. You must state the measurements that are made and how they are used.

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..............................................................................................................
..............................................................................................................

(b) The speed of a kart and driver is recorded from the start of the race. The kart starts from rest and accelerates uniformly until it reaches check point X. Its speed at X is 12 metres per second. The time taken to reach X is 4 seconds.

(i) Draw a speed-time graph for the motion of the kart from the start until it reaches check point X. Units and numerical values must be shown on both axes.

<table>
<thead>
<tr>
<th>speed in</th>
</tr>
</thead>
<tbody>
<tr>
<td>..........</td>
</tr>
<tr>
<td>..........</td>
</tr>
<tr>
<td>..........</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>time in</th>
</tr>
</thead>
<tbody>
<tr>
<td>..........</td>
</tr>
</tbody>
</table>
15. (b) (continued)

(ii) Calculate the acceleration of the kart between the start and check point X.

Space for working and answer

(c) Some spectators at the race track are finding it difficult to see the race. One spectator uses a periscope. A periscope can be made from a cardboard tube with two plane mirrors as shown.

Complete the diagram to show how the rays of light travel through the periscope to the spectator’s eye.
16. A climber of weight 550 newtons takes 40 seconds to reach the top of a 20 metre high climbing wall.

(a) What is the minimum upward force she exerts while climbing the wall?

(b) Calculate the minimum work done by the climber to reach the top of the wall.

Space for working and answer

(c) Calculate her power during this climb.

Space for working and answer

(d) Explain why the climber uses chalk on her hands as she climbs the wall.

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17. A house is designed to conserve as much energy as possible.

(a) Heat energy can be lost from the house by a variety of means. Insulation is used to reduce heat loss.

Match the correct type of insulation given in the word bank with each type of heat loss.

Use each answer once only.

<table>
<thead>
<tr>
<th>foil-backed plasterboard</th>
<th>double glazing</th>
<th>loft insulation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Type of heat loss</strong></td>
<td><strong>Correct insulation</strong></td>
<td></td>
</tr>
<tr>
<td>Conduction</td>
<td>foil-backed plasterboard</td>
<td></td>
</tr>
<tr>
<td>Convection</td>
<td>double glazing</td>
<td></td>
</tr>
<tr>
<td>Radiation</td>
<td>loft insulation</td>
<td></td>
</tr>
</tbody>
</table>

The temperature in the house is kept at a constant value while the temperature outside changes.

The graph shows the temperature inside the house and the temperature outside the house over a 24 hour period.

(b) Write down the time at which heat loss from the house is greatest.

..................................................................................................................................................................................
18. Increasing the amount of electricity generated from renewable sources is important for the future of our country.

(a) At present, fossil fuels are the main source of energy.
   State one problem with this source of energy.
   ..............................................................................................................

(b) The bar chart shows the main energy sources used in Scotland.

Use the names of the energy sources in the bar chart to complete the table.

<table>
<thead>
<tr>
<th>Renewable</th>
<th>Non-renewable</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>
18. (continued)

(c) A nuclear power station with a power output of 1.5 gigawatts could be replaced by pumped hydroelectric power stations.

(i) Some of the stages in a nuclear power station are shown.

At what stage is the main energy transformation:

(A) kinetic → electrical;

.......................................................... .......................................................... 1

(B) nuclear → heat?

.......................................................... .......................................................... 1

A pumped hydroelectric power station produces 0.25 gigawatts of power.

(ii) Give one advantage of a pumped hydroelectric station over a normal hydroelectric station.

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(iii) How many pumped hydroelectric stations would be needed to replace the nuclear power station?

Space for working and answer

.......................................................... .......................................................... 1

[Turn over]
19. 

(a) State an optical device that can split white light into different colours.

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(b) Astronomers can use the peak wavelength of light emitted by stars to provide information about their temperature. The peak wavelength corresponds to a particular colour.

Information about three stars is given in the table.

<table>
<thead>
<tr>
<th>Star</th>
<th>Colour of peak wavelength in visible spectrum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rigel</td>
<td>Blue</td>
</tr>
<tr>
<td>Betelgeuse</td>
<td>Red</td>
</tr>
<tr>
<td>Sun</td>
<td>Green</td>
</tr>
</tbody>
</table>

The shorter the peak wavelength, the hotter the star is.

(i) Which star is hottest?

................................................................. .................................................................

(ii) Is the sun hotter, colder or the same temperature as Betelgeuse?

................................................................. .................................................................

(c) Telescopes can detect visible light waves.

Name one other type of wave that can be detected using a telescope.

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19. (continued)

(d) The planet Venus is often seen in the evening and morning close to the horizon.

Draw light rays on the diagram to show how observers on Earth are able to see Venus.

You must put arrows on the rays to show their direction.

[Diagram of Earth, Venus, and Sun with light rays indicated]
20. Astronomers study space.

Complete the sentences by circling the correct answers.

(a) The Earth is a \{ \text{planet} \} which orbits the Sun. The Earth has one natural \text{satellite} called the \{ \text{International Space station} \}, \{ \text{Hubble telescope} \}, \{ \text{Moon} \}. \hspace{1cm} 1

(b) The Sun is at the centre of our \{ \text{solar system} \}, \{ \text{universe} \}, \{ \text{galaxy} \}. Light from the Sun takes \{ 8 \text{ seconds} \}, \{ 4.3 \text{ years} \}, \{ 8 \text{ minutes} \} to travel to the Earth. \hspace{1cm} 1

(c) The nearest star to the Earth is \{ \text{Sirius} \}, \{ \text{Mars} \}, \{ \text{the Sun} \}. \hspace{1cm} 1

All of space is known as the \{ \text{Milky Way} \}, \{ \text{solar system} \}, \{ \text{universe} \}. \hspace{1cm} 1

[END OF QUESTION PAPER]
ADDITIONAL SPACE FOR ANSWERS

Make sure you write the correct question number beside each answer.
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