Wellingborough School
Founded 1595

SAMPLE PAPER

PHYSICS
SCHOLARSHIP EXAMINATION 16+

Candidate Number:

Time:

- 1 ½ hours

Instructions to Candidates:

- Answer ALL the questions using the spaces provided on the examination paper
- ALL necessary working must be shown
- You will need a calculator

1. Fig. 1.1 shows a simple pendulum being used by a student to investigate the energy changes at various points in the pendulum's swing.

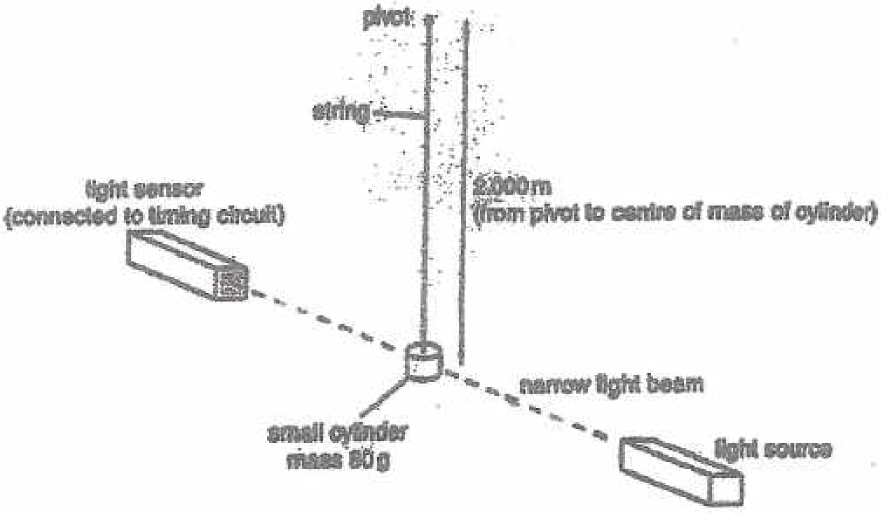

Fig. 1.1

(a) When the string is displaced by a small angle from the vertical, the height of the cylinder changes so that its centre of mass is now 1.932 m below the pivot. Determine the gravitational potential energy gained by the cylinder. Use $g = 10\ m/s^2$

gravitational potential energy gained = ...

[3]

(b) The cylinder is released from the displaced position in (a). Calculate the expected speed of the cylinder when the string is vertical.

energy speed = ...

[2]

(c) As the string passes through the vertical, the narrow beam of light is interrupted by the cylinder for 22 ms. The cylinder has a diameter of 2.5 cm.

(i) Calculate the actual speed of the cylinder.

actual speed = ...

(ii) Suggest how the difference between the actual and expected speeds could occur.

....

....

....

.... [3]

[Total: 8]

2. The racing car shown in Fig. 2.1 uses a Kinetic Energy Recovery System (KERS). This system stores within the car some of the kinetic energy lost when the car slows down for a corner. The driver can later release the stored energy when maximum power is required.

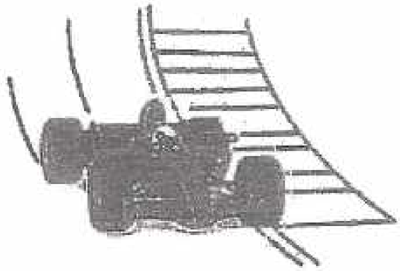

Fig. 2.1

(a) The car approaches a corner and decelerates from 82 m/s to 61 m/s in 0.90 s.
Calculate the decelaration.

deceleration = ...
[2]

(b) (i) The energy lost during the braking in **(a)** is 8.4×10^5 J.40% of this lost energy is directed to the KERS system. Determine the amount of energy stored.

energy stored = ...

(ii) The driver later uses all of this stored energy to give 60 kW of useful extra power for 3.0 s.
Calculate the energy released.

energy released = ...

(iii) Calculate the efficiency of the KERS system.

efficiency = ...
[4]

(c) Suggest a possible device to store energy when a moving vehicle slows down. For this device, state the change that occurs as more energy is stored.

device ....

change ....

....

....
[2]

[Total: 8]

3. A sealed balloon containing some helium gas is released and rises into the upper atmosphere. As the balloon rises the temperature of the helium falls and the balloon expands.

Explain, in terms of atoms,

(a) the effect of the fall in temperature on the helium pressure,

....

....

....

....

.... [3]

(b) the effect of the expansion of the balloon on the helium pressure.

....

....

....

....

.... [3]

[Total: 6]

4. Fig. 5.1 shows an X-ray tube.

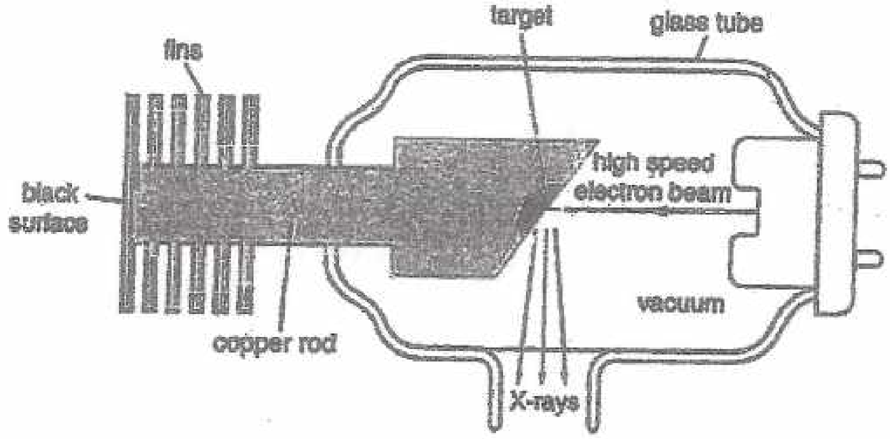

Fig. 5.1

In the production of X-rays, the target gets very hot. Thermal energy must be removed from the target. The tube has several design features to enable this to happen.

For each of the following types of energy transfer, describe how the design of the tube increases the rate of energy transfer. State where the thermal energy transfer mostly happens, the particular design feature that increases the rate of this transfer, and a brief explanation.

(a) conduction

where ....

design feature ....

explanation ....

....

[3]

(b) convection

where ....

design feature ....

explanation ....

....

[3]

(c) radiation

where ....

design feature ....

explanation ....

.... [3]

[Total: 9]

5. (a) State an approximate value for

(i) the speed of sound in air, ...

(ii) the speed of light in air. ....

[2]

(b) Use your value from **(a) (i)** to calculate the frequency of a sound wave that has wavelength of 1.2 m.

frequency = ...

[2]

(c) A meteorologist observes an approaching thunderstorm and records a time difference of 4.8 s between seeing a lightning flash and hearing the thunder that follows.

(i) Calculate the distance of the thunderstorm from the meteorologist.

distance = ...

(ii) State an assumption you made when calculating this distance.

....

....

....

[2]

[Total: 6]

6. Fig. 8.1 shows a loudspeaker cone oscillating to produce sound waves.

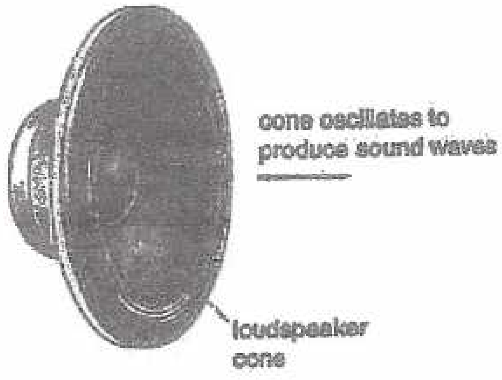

Fig. 8.1

(a) As the sound wave passes a point, it produces regions of higher and lower pressure. State the names of these regions.

higher pressure ....

lower pressure ....

[2]

(b) Describe how the movement of the loudspeaker cone produces these regions of different pressure.

higher pressure ....

....

lower pressure ....

....

[2]

(c) State the effect on the loudness and pitch of the sound from the loudspeaker when

(i) the amplitude increases but the frequency of the sound stays the same.

loudness ....

pitch ....
[2]

(ii) the amplitude stays the same but the frequency increases.

loudness ....

pitch ....
[2]

[Total: 6]

7. In the laboratory demonstration shown in Fig. 11.1, a copper rod rolls at a steady speed down the sloping parallel copper rails. The rails are in the region of a strong magnetic field that acts vertically downwards.

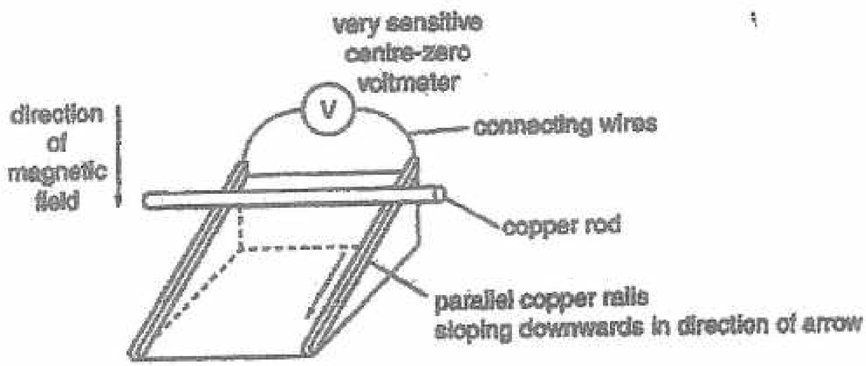

Fig. 11.1

(a) Explain why the voltmeter shows a deflection.

....

....

....

.... [2]

(b) State, with reasons, the effect on the voltmeter deflection of the following changes:

(i) increasing the strength of the magnetic field,

deflection ....

reason ....

....

....

(ii) slightly increasing the slope of the copper rails,

deflection ....

reason ....

....

....

(iii) changing the direction of the magnetic field so it is parallel to the copper rails and directed down the slope.

deflection ....

reason ....

....

....

[4]

[Total: 6]

8. The most abundant stable isotope of strontium is strontium-88. Its nucleon number is 88 and its proton number is 38. In nuclide notation it is written $^{x}_{y}Sr$.

(a) Write down

(i) the values of x and y for strontium-88,

x = ...

y = ...

(ii) the number of neutrons in a nucleus of strontium-88,

....

(iii) the number of electrons in a neutral atom of strontium-88,

....
[3]

(b) Strontium-90 is a radioactive isotope produced by nuclear reactions. State how the structure of this isotope differs from that of strontium-88.

....

....

....

....

....
[2]

[Total: 5]

9. (a) Define *acceleration*. Explain any symbols in your definition.

....

.... [1]

(b) Fig. 1.1 shows a graph of speed against time for a train. After 100 s the train stops at a station.

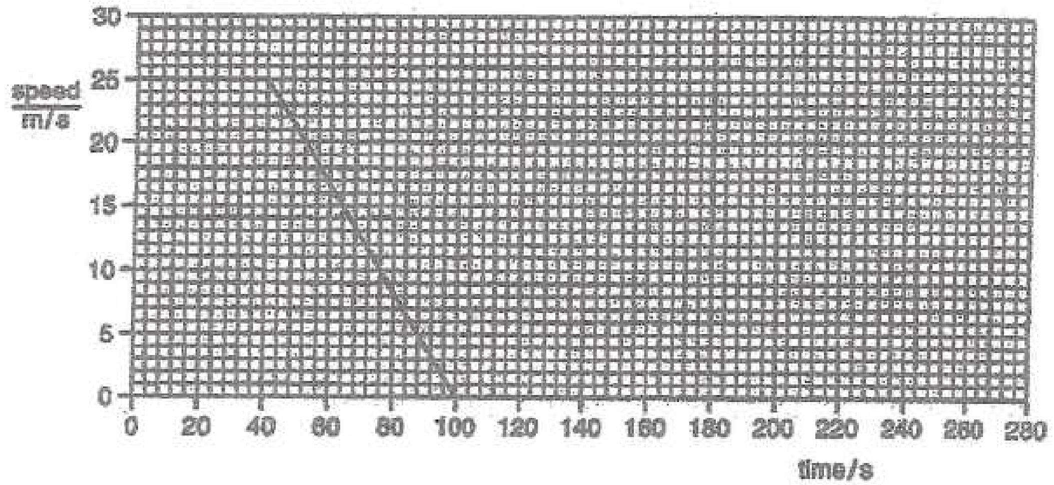

Fig. 1.1

(i) For the time interval between 40 s and 100 s, calculate the distance between travelled by the train.

distance .... [2]

(ii) The train stops for 80 s, then accelerates to 30 m/s with an acceleration of 0.60 m/s². It then travels at constant speed.

Complete the graph for the interval 100 s to 280 s, showing your calculations in the space below.

[5]

[Total: 8]

10. (a) Energy from the Sun evaporates water from the sea. Some of this water eventually drives a hydroelectric power station. Give an account of the processes and energy changes involved.

....

....

....

....

....

....

....

....

....

....
[4]

(b) In a hydroelectric power station, 200 000 kg of water per second fall through a vertical distance of 120 m. The water passes through turbines to generate electricity, and leaves the turbines with a speed of 14 m/s.

(i) Calculate the gravitational potential energy lost by the water in 1 second. Use $g = 10 \text{ m/s}^2$.

potential energy lost = ...
[2]

(ii) Calculate the kinetic energy of the water leaving the turbines in 1 second.

kinetic energy = ...

[2]

[Total: 8]

11. (a) A student tests to see whether certain materials conduct electricity. He uses the circuit in Fig. 8.1 and connects the materials in turn in the gap between P and Q.

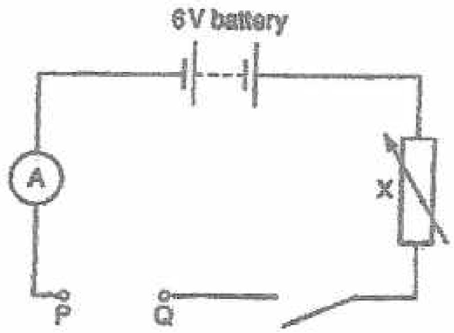

Fig. 8.1

(i) What is the purpose of component X in the circuit?

....

.... [1]

(ii) State how the student can tell if a certain material conducts electricity?

....

.... [1]

(iii) Which of the following materials is a good conductor of electricity? Put a tick alongside each material that is a good conductor.

copper	☐
glass	☐
iron	☐
nylon	☐
perspex	☐

[1]

(b) The student now connects a small heater in the gap in the circuit, as shown in Fig. 8.2. He wishes to determine the resistance of the heater.

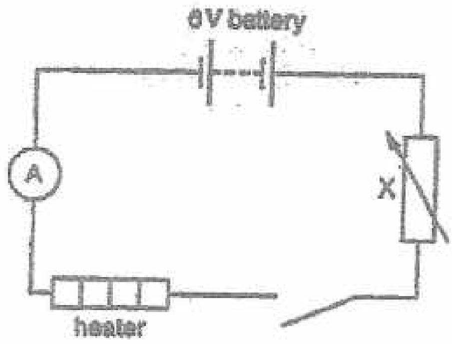

Fig. 8.2

(i) What other meter must he connect in the circuit, in order to determine the resistance?

....

[1]

(ii) On Fig. 8.2, draw this meter in the correct position in the circuit.

[1]

(c) Fig. 8.3 shows a radiant electric fire with 3 heating elements, each of which operates at full temperature when 250 V is connected across it.

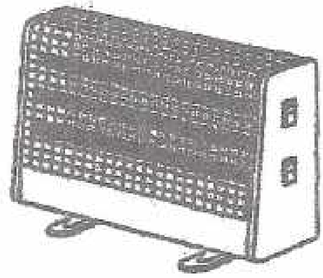

Fig. 8.3

(i) Fig. 8.4 shows an incomplete circuit diagram of the fire.

There are 2 switches. The top switch controls one heating element and the bottom switch controls two heating elements connected in parallel.

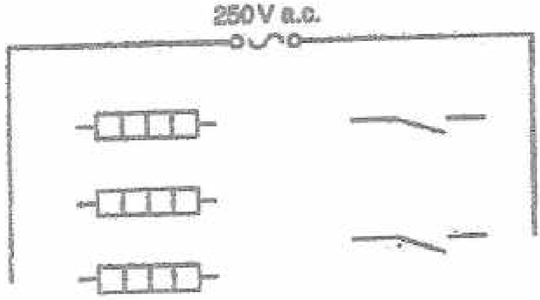

Fig. 8.4

Complete Fig. 8.4, showing all the electrical connections. [2]

(ii) The current in one heating element is 2.5 A when it is connected to the 250 V supply.

Calculate the resistance of the heating element.

resistance = ... [4]

(iii) All three heating elements are switched on. Which statement about the total resistance of the electric fire is correct? Tick one box.

no resistance ☐

smaller resistance than in **(c) (ii)** ☐

same resistance than in **(c) (ii)** ☐

larger resistance than in **(c) (ii)** ☐

[1]

[Total: 12]

12. The counter in Fig. 11.1 records the total number of times that a radiation is detected whilst the counter is switched on.

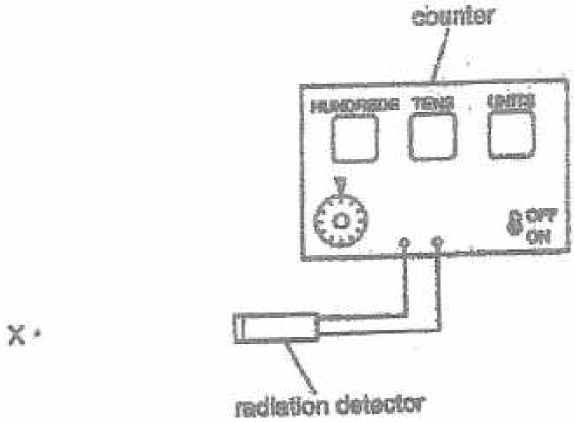

Fig. 11.1

(a) With no radioactive source present, the counter is set to zero and then switched on for 4 minutes.

After this time, the counter reads:

(i) What radiation is the apparatus detecting?

.... [1]

(ii) Calculate the average count rate of this radiation.

count rate = ... counts/min [2]

(b) (i) Point X is 25 cm from the radiation detector. A source that is known to be highly radioactive is placed at X.

The counter is reset to zero, and the count again taken for 4 minutes.

The counter now reads:

State what type of radiation is being emitted by the source.

....

[1]

(ii) The source is moved to a position 2 cm from the detector. The counter is set to zero and restarted. The counter reading after counting for 4 minutes is:

Estimate the count rate due to the radioactive source alone.

count rate = ... counts/min

[3]

[Total: 7]

END OF TEST