



WESTMINSTER SCHOOL
THE CHALLENGE 2022

PHYSICS

Thursday 28 April 2022

Time allowed: 30 minutes

Please write in black or blue ink.

Calculators are allowed.

Write your answers in the spaces provided.

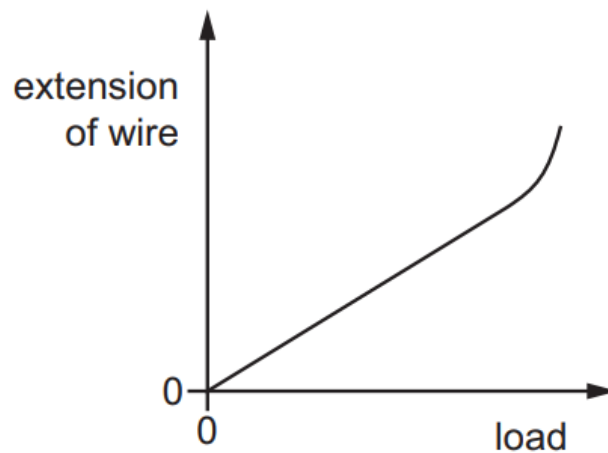
For examiner use only

Total		
Mark		

P1 (Multiple Choice – 10 marks)

Choose A,B,C,D or E for each of the following questions.

- a) The graph shows the extension of a piece of copper wire as the load on it is increased. What does the graph show?



- A: At a certain load, the wire becomes easier to extend.*
- B: At a certain load, the wire becomes harder to extend.*
- C: The load and the extension are directly proportional for all loads.*
- D: The load and the extension are inversely proportional for all loads.*
- E: There is an exponential relationship between the load and extension.*

- b) A substance consists of particles that are close together and moving past each other at random. The average speed of the particles is gradually increasing. What best describes the substance?

A: a gas being heated

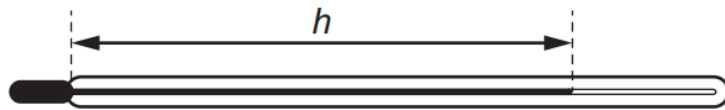
B: a liquid being heated

C: a liquid undergoing solidification

E: a gas condensing

D: a solid being heated

- c) The mercury-in-glass thermometer shown has a linear scale.



At a temperature of 100°C , h has a value of 28 cm. At 80°C , h has a value of 24 cm. What is the value of h when the temperature is 0°C ?

A: 0.0 cm

B: 1.2 cm

C: 2.8 cm

D: 4.0 cm

E: 8.0 cm

d) A ship that is stationary on the surface of the sea sends pulses of sound vertically downwards towards the sea bed. Each pulse that reflects from the sea bed is received 1.0 s after it is sent out. A whale swims under the boat and a pulse is received 0.60 s after it is sent out. The speed of sound in sea water is 1500 m/s. What is the distance of the whale above the sea bed?

A: 300 m

B: 450 m

C: 600 m

D: 750 m

E: 1000 m

e) Which of these is not a unit for the measurement of speed:

A: metre per second

B: kilometre per hour

C: light year

D: mile per hour

E: knot

f) A charged plastic ball is at rest. Which fields are found in the region surrounding the ball? (Ignore the magnetic field of the Earth.)

A: electric only

B: electric, gravitational and magnetic

C: electric and gravitational only

D: electric and magnetic only

E: gravitational and magnetic only

g) Which of these is a renewable source of energy?

A: Coal

B: Biomass

C: Nuclear Fusion

D: Wind

E: Oil

h) When a person looks at their reflection in a plane (flat) mirror, how does the image appear?

A: Not inverted or rotated at all

B: Inverted vertically only

C: Inverted laterally only

D: Inverted both laterally and vertically

E: Rotated by 180°

i) Approximately how long does the Moon take to orbit the Earth once:

A: 1 hour

B: 1 day

C: 1 week

D: 1 month

E: 1 year

j) A certain mass m accelerates at 10 m/s^2 when the unbalanced force on it is F . What would the acceleration of half the mass be under the action of double the force?

A: 2.5 m/s^2

B: 5 m/s^2

C: 10 m/s^2

D: 20 m/s^2

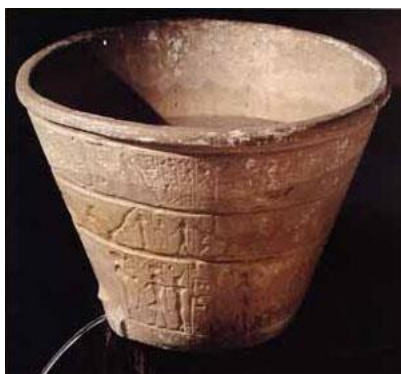
E: 40 m/s^2

[10]

2. The First Experiment¹

In the fifth century BC, Empedocles argued that everything in the cosmos was made of four elements: earth, air, fire and water. Three of those elements were easy to see and demonstrate but many people did not believe in air. To demonstrate the existence of air, Empedocles took a clepsydra (a jar with a spout), turned it upside down, put his thumb over the spout and immersed it in water. When he took his thumb off the spout, bubbles of air rose to the surface.

- a) This is a picture of a clepsydra. Explain how it was used as a water clock by the ancient Egyptians.



[2]

- b) Thousands of years later, Robert Boyle found the relationship between the volume and pressure of a fixed mass of gas at constant temperature before and after an expansion or compression:

$$\text{Pressure before} \times \text{Volume before} = \text{Pressure after} \times \text{Volume after}$$

- (i) A bubble of air at pressure 101 000 Pa has volume 1.20 cm³. What will its volume be if you double the pressure on the bubble? Show your working and give your answer with an appropriate unit and number of significant figures.

[2]

¹ <https://alunsalt.com/the-first-experiment-cc822d326fda> (accessed 08/03/2022)

- (ii) State and explain what you expect to have happened to each bubble's size as it rose to the surface in Empedocles' experiment.

[2]

- c) This is a bubble from the clepsydra that is rising through water. Add arrows to show the forces acting on it. Label the arrows.



[2]

- d) On the following axes, sketch a graph to show the speed of a bubble from the moment it leaves the clepsydra. You do not need to include any numbers. Annotate your graph to justify the shape that you have drawn.



[4]

- e) You have the benefit of modern technology and knowledge. Describe an experiment that you could do to prove the existence of air. You are encouraged to include appropriate diagrams.

[3]

- f) At the end of his life, Empedocles is said to have decided to test whether he was immortal. He jumped into Mount Etna. If he were mortal he would die; if immortal he would live. Nothing was found of him but for one sandal.

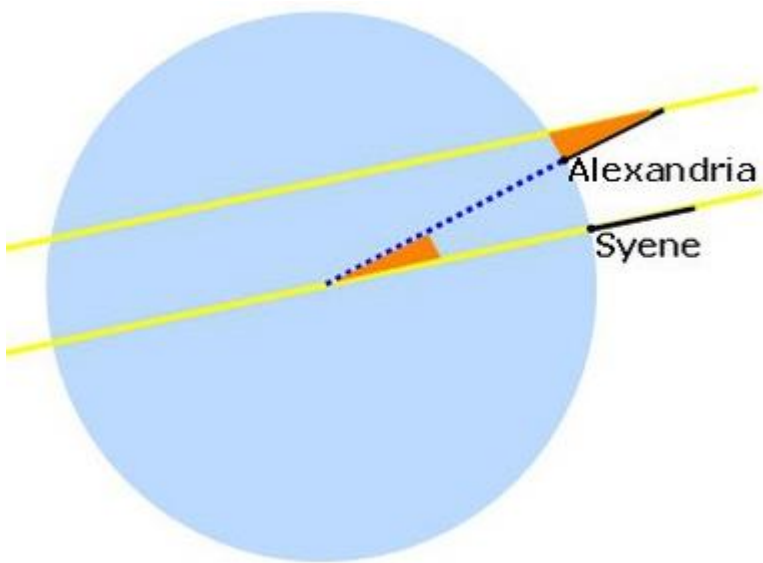
This is a picture of Mount Etna.



Bonus question: which island do you think Empedocles came from?

3. In 200 BC, Eratosthenes estimated the Earth's circumference². Based in Alexandria in Egypt, he read that there was a well in a city named Syene, South of Alexandria, in which the sun's reflection could be seen at noon on a particular day of the year. This told him that the sun was directly overhead.

The figure below³ shows how he put identical sticks (of length 100 cm) into the ground at Syene and at Alexandria and measured the length L of the shadow cast by the stick at Alexandria at mid-day. The yellow lines represent parallel sun rays. The distance d between Alexandria and Syene was measured using a trundle wheel.



- a) Indicate length L and distance d on the figure above.

[1]

- b) Use the following data to calculate a value for the circumference of the Earth.

$$L = 12.3 \text{ cm}$$

$$d = 5000 \text{ stadia (where } 1 \text{ stadia} = 155 \text{ m)}$$

[2]

² <https://www.scientificamerican.com/article/measure-earths-circumference-with-a-shadow/>

³ https://www.sciencebuddies.org/science-fair-projects/project-ideas/Astro_p018/astronomy/calculating-the-circumference-of-the-earth

c) Eratosthenes's measurement was 46,250 km.

(i) Calculate the circumference of the planet using today's measurement of Earth's radius (6400 km).

[1]

(ii) By what percentage was Eratosthenes's measurement wrong?

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