Rewarding Learning

ADVANCED
General Certificate of Education
2022 Reserve Series

Centre Number

Candidate Number

Physics

Assessment Unit A2 1
assessing
Deformation of Solids, Thermal Physics, Circular Motion, Oscillations and Atomic and Nuclear Physics

[APH11]

APH11

FRIDAY 24 JUNE, AFTERNOON

TIME

2 hours.

INSTRUCTIONS TO CANDIDATES

Write your Centre Number and Candidate Number in the spaces provided at the top of this page.
You must answer the questions in the spaces provided.
Do not write outside the boxed area on each page or on blank pages.
Complete in black ink only. **Do not write with a gel pen.**
Answer **all eight** questions.

INFORMATION FOR CANDIDATES

The total mark for this paper is 100.
Figures in brackets printed down the right-hand side of pages indicate the marks awarded to each question or part-question.
Quality of written communication will be assessed in Question **8**.
Your attention is drawn to the Data and Formulae Sheet which is inside this question paper.
You may use an electronic calculator.

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1 **(a)** **(i)** State Hooke's law.

[2]

A tendon in the human body is extended by 0.11 cm when stretched by a load of 850 N. When the load is decreased by 225 N, the extension is 0.09 cm.

(ii) Show that the tendon does not obey Hooke's law over this range of load.

[4]

(iii) The tendon behaves elastically until the strain in the tendon reaches 8%. Explain how the tendon reacts to a load being removed when the strain is below and above 8%.

[2]

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(b) The Young modulus is an important property of materials.

(i) Describe the difference in a material that has a high Young modulus compared to a lower Young modulus.

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____ [1]

(ii) The Young modulus of a human bone is 14.8 GPa. The tibia bone in a person's leg has a length of 0.365 m and a diameter of 0.024 m.

The tibia will break if the compressive force on it exceeds 4×10^5 N.

The person falls and the resulting impact with the ground causes the tibia bone to compress to a length of 0.347 m.
Show the suitable calculations used to determine if the tibia will break.

Calculations:

Will the tibia break? Yes ☐ No ☐ [6]

2 The London Eye is an observation wheel situated on the bank of the river Thames. The wheel of the London Eye has a diameter of 120 m, as shown in **Fig. 2.1**.

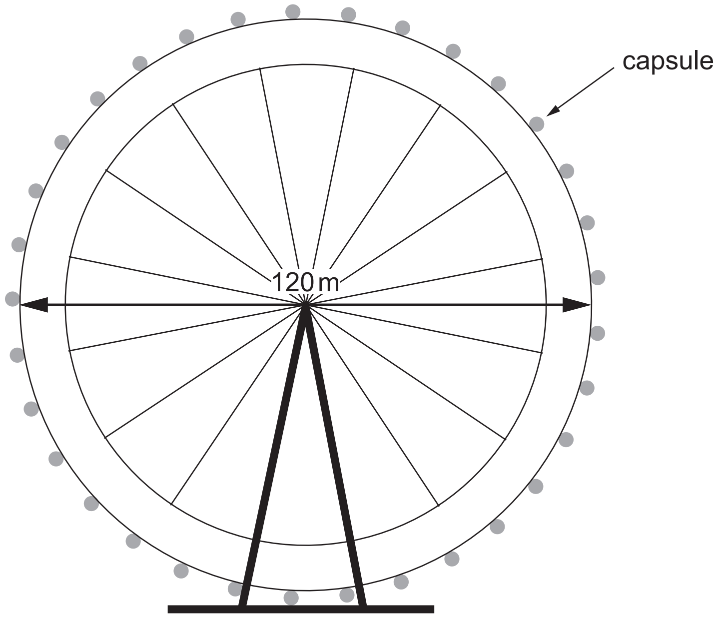

Fig. 2.1

The capsules around the outside each have a mass of 1000 kg. In one capsule there are 15 passengers with an average mass of 70 kg each.

The capsules move with a constant linear speed of $0.26\,\text{m s}^{-1}$.

(a) Calculate the time it takes for the wheel to make one complete revolution. Give your answer in minutes.

Time for 1 revolution = ____________ minutes [4]

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(b) (i) Calculate the centripetal acceleration required to keep the capsule with the passengers in it moving at the linear speed of $0.26\,m\,s^{-1}$.

Acceleration = _____________ $m\,s^{-2}$ [3]

(ii) Determine the centripetal force required to keep the capsule with the passengers in it moving at this speed.

Force = _____________ N [3]

3 A horse-shoe is made from mild steel which has a specific heat capacity of 510.8 $\text{J kg}^{-1}\,\text{K}^{-1}$.

The shoe has a mass of 0.42 kg. It is heated to a very high temperature in a gas-fired furnace so that it can be hammered into the correct shape.

The shoe is cooled down by dropping it into 2500 cm^3 of water at 15 °C in a bucket of mass 0.18 kg made from a material of specific heat capacity 1550 $\text{J kg}^{-1}\,\text{K}^{-1}$.

The specific heat capacity of water is 4186 $\text{J kg}^{-1}\,\text{K}^{-1}$ and the density of water is 1 g cm^{-3}.

(a) If the final temperature of the water is 27 °C, calculate the temperature θ of the shoe when it is placed in the bucket of water.

θ = ______________ ° [5]

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(b) The furnace is supplied with gas from a metal cylinder.

(i) State what happens to the pressure of the gas inside the cylinder as the gas is released. Explain, with reference to the ideal gas equation, why this happens. Assume that the temperature of the gas in the cylinder does not change.

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____

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____ [4]

(ii) The gas cylinder has a volume of $0.65\,m^3$. The gas inside the cylinder is at a pressure of 2.2 MPa and has a constant temperature of 15 °C. If 75 moles of the gas leave the cylinder, calculate the new pressure inside the cylinder.

Pressure = ______________ MPa [5]

(iii) Calculate the total kinetic energy of all the gas molecules that are left in the cylinder.

Total k.e. = ______________ J [4]

[Turn over

4 Boyle's law describes the relationship between the pressure and volume of a gas under certain conditions.

(a) State Boyle's law.

____

____ [2]

(b) Describe an experiment to verify Boyle's law graphically.

Include in your answer:

- a labelled diagram of the apparatus required
- a description of the procedure followed to obtain the results
- a sketch of the graph that will be drawn.

(i) Diagram of the apparatus:

[3]

(ii) Description of the procedure.

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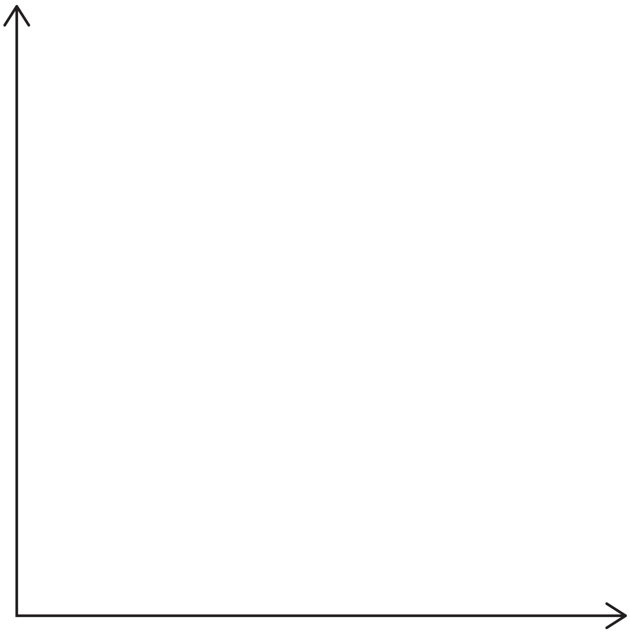
____ [3]

(iii) Sketch of the graph.



[2]

[Turn over

5 The needle of a sewing machine moves with simple harmonic motion.

(a) Define simple harmonic motion.

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____

____ [2]

(b) The needle of a sewing machine oscillates vertically through a total distance of 18.0 mm with a frequency of 5.0 Hz. When the needle is at its maximum height, the cloth that is being stitched is 6.0 mm below the point of the needle as shown in **Fig. 5.1**.

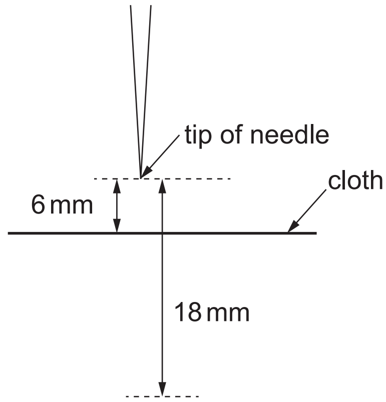

Fig. 5.1

(i) Calculate the acceleration of the needle when it reaches the cloth.

Acceleration = ______________ m s^{-2} [6]

(ii) Calculate the time that the needle remains under the cloth before coming back up through the cloth again.

Time taken = _____________ s [5]

6 **(a)** A vibrating system can undergo resonance. Explain what is meant by resonance and under what condition resonance will occur for a vibrating system.

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____ [2]

(b) Give one example where resonance is useful and one example where resonance should be avoided.

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____ [2]

(c) Vibrating systems can be damped. Explain what is meant by damping and describe the effect that damping has on resonance.

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____ [3]

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(Questions continue overleaf)

7 Cobalt-60, $^{60}_{27}Co$, is a man-made radioisotope that is used for cancer therapy. It decays to nickel Ni with the emission of a beta-minus particle and two high energy gamma rays.

(a) (i) Write the equation for the decay of $^{60}_{27}Co$.

[3]

(ii) The emitted gamma ray photons have energies of 1.17 MeV and 1.33 MeV. The mass of a $^{60}_{27}Co$ nucleus given to five decimal places is 59.93382 u and an electron given to five decimal places is 0.00055 u.

Calculate the mass of the Ni nucleus produced in the decay. Give your answer in atomic mass units to five decimal places.

Mass = ______________ u [6]

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(b) The half-life of $^{60}_{27}Co$ is 5.27 years. The initial activity of a source to be used in the therapy is 1.85×10^{10} Bq.
The source is too weak to be useful when its activity falls to 1.32×10^{10} Bq.

(i) Explain what is meant by an activity of 1 Bq.

____

____ [1]

(ii) Calculate for how long the source will remain useful.

Give your answer in years.

Time = ______________ years [3]

[Turn over

(c) (i) The binding energy per nucleon of a nucleus of iodine-127, $^{127}_{53}\mathrm{I}$, is 8.45 MeV.

Calculate the binding energy of the iodine-127 nucleus.

Binding energy = _____________ MeV [1]

(ii) Calculate the radius of the $^{127}_{53}\mathrm{I}$ nucleus. Give your answer in metres.

$r_0 = 1.2\,\mathrm{fm}$

radius = _____________ m [2]

(iii) Calculate the density of the $^{127}_{53}\text{I}$ nucleus in atomic mass units per metre^3.

The volume of a sphere is $\frac{4}{3}\pi r^3$.

Density = ____________ u m^{-3} [3]

Quality of written communication will be assessed in this question.

8 Outline the processes that take place in a nuclear fission power station to produce electricity in a safe, controlled manner.

[8]

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For Examiner's use only	
Question Number	**Marks**
1	
2	
3	
4	
5	
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7	
8	
Total Marks	

Examiner Number