Pat Carson and Roy White

CCEA A2

PHYSICS QUESTIONS

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An imprint of Colourpoint Creative Ltd
Colourpoint House
Jubilee Business Park
21 Jubilee Road
Newtownards
County Down
Northern Ireland
BT23 4YH

Tel: 028 9182 0505
E-mail: sales@colourpoint.co.uk
Web site: www.colourpoint.co.uk

The Authors

Roy White taught Physics to A level for over 30 years in Belfast. He works for an examining body as Chair of Examiners for Double Award Science, Principal Examiner for GCSE Physics and Principal Examiner for A level Life and Health Sciences. In addition to this text, he has been the author or co-author of three successful books supporting the work of science teachers in Northern Ireland.

Pat Carson has been teaching Physics to A level for over 30 years in Belfast and Londonderry. He works for an examining body as Chief Examiner for GCSE Physics. In addition to this text, he has been co-author on a number of books supporting the work of Physics teachers at AS and A2 level.

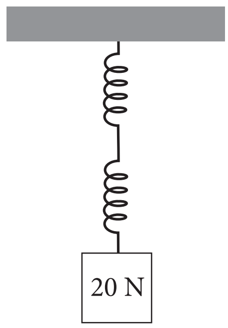
Note: it is the responsibility of teachers and lecturers to carry out an appropriate risk assessment when planning any practical activity. Where it is appropriate, they should consider reference to CLEAPPS guidance.

Contents

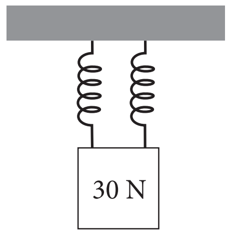
Unit 4.1 (A2 1)
Deformation of Solids

1. A spring has a total length of 15 cm when a force of 5 N is applied to it. When a force of 7 N is applied to the spring its total length is 19 cm.
   (a) Calculate the unstretched length of the spring.
   (b) Calculate the value of the spring constant k in the equation $F = kx$ where F is the applied force and x is the extension of the spring.
   (c) Calculate the strain energy stored in the spring when a force of 4 N is applied to the spring.

2. Two identical springs with a spring constant of 400 N m^{-1} are arranged as shown on the right. Calculate the total extension when a force of 20 N is applied to the end of the springs. Hint: the force of 20 N is applied to each spring.

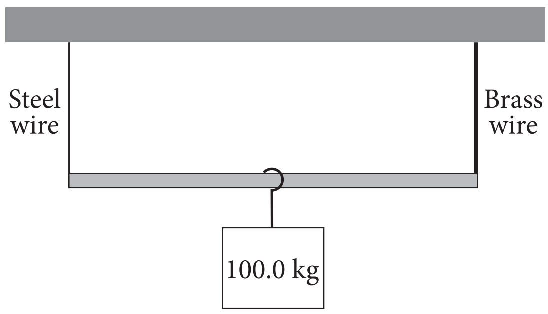


3. The springs used in question 2 are now arranged as shown on the right. Calculate the total extension when a force of 30 N is attached as shown. Hint: the force of 30 N is equally divided between the two springs.

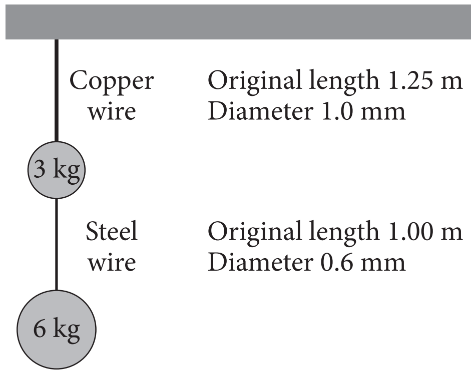


4. A steel wire is of original length 1.5 m and diameter 0.5 mm. One end of the wire is fixed and a force of 10 N is applied at the other end. The Young modulus of steel is 2.1×10^{11} Pa.
   (a) Calculate the extension of the wire.
   (b) Calculate the energy stored in the stretched wire.

5. A mass of 100.0 kg is suspended as shown on the right. One wire is made of steel, the other of brass. Each wire is 1.2 m long when the light rigid bar is horizontal. The bar remains horizontal as the wires stretch. The diameter of the steel wire is 0.5 mm. The Young modulus of steel is 2.1×10^{11} Pa, and the Young modulus of brass is 9.0×10^{10} Pa.
   (a) Calculate the tension in each wire.
   (b) Calculate the extension of the steel wire.
   (c) Calculate the diameter of the brass wire.

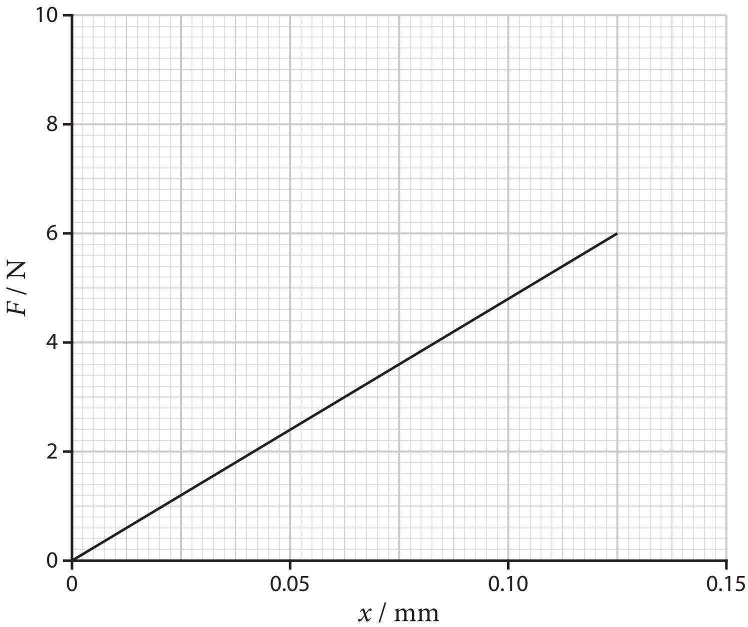


6. Two wires of negligible mass are arranged as shown in the diagram on the right. Weights are attached as shown. The lengths are those before the wires were stretched. The Young modulus of steel is 2.1×10^{11} Pa and the Young modulus of copper is 1.2×10^{11} Pa.
   (a) Calculate the extension of each wire.
   (b) Calculate the energy stored in the wires.



7. A wire was stretched. The force applied, F and the resulting extension, x are shown on the graph on the right. The original length of the wire was 2.5 m and its diameter was 0.4 mm.

   Using the graph and the values given, calculate the Young modulus of the material of the wire.

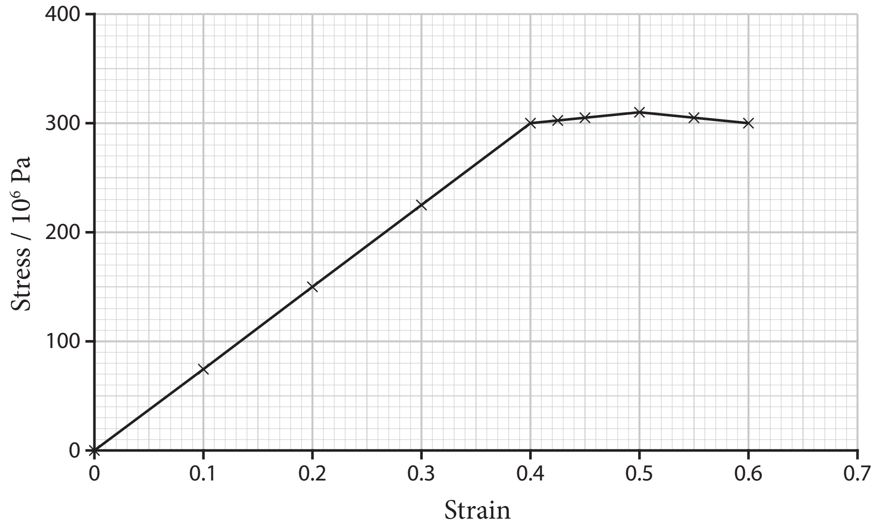


8. (a) Explain the difference between the limit of proportionality and the elastic limit.
   (b) Sketch a graph of stress (y-axis) against strain (x-axis) for a material that is stretched. On the graph mark the limit of proportionality and the elastic limit.

9. A concrete column of cross-sectional area 1.5 m^2 supports a force of 250 kN.
   The Young modulus of concrete is 3×10^{10} Pa.
   (a) Calculate the stress within the column.
   (b) Calculate the compression of the column if its unloaded length is 6 m.

10. The area of cross section of a steel wire is 0.025 cm^2.
    The unstretched length of the wire is 5.0 m.
    The Young modulus of steel is 2.1×10^{11} Pa.
    Calculate the work done in stretching the wire by 60 cm.

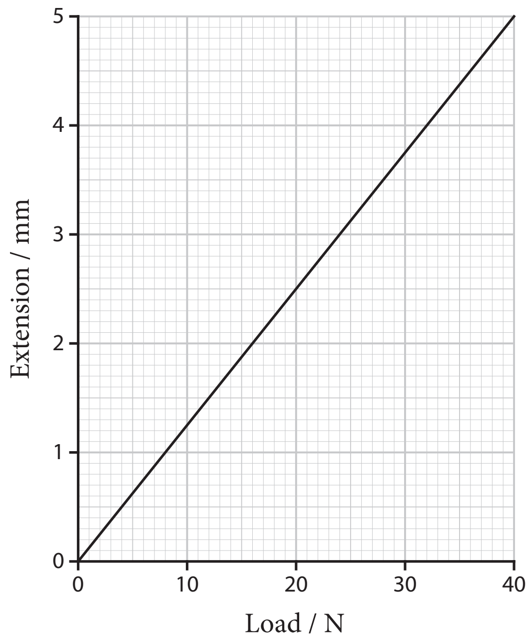
11. The stress/strain values for a material are shown in the graph on the right. Calculate the Young modulus of the material.



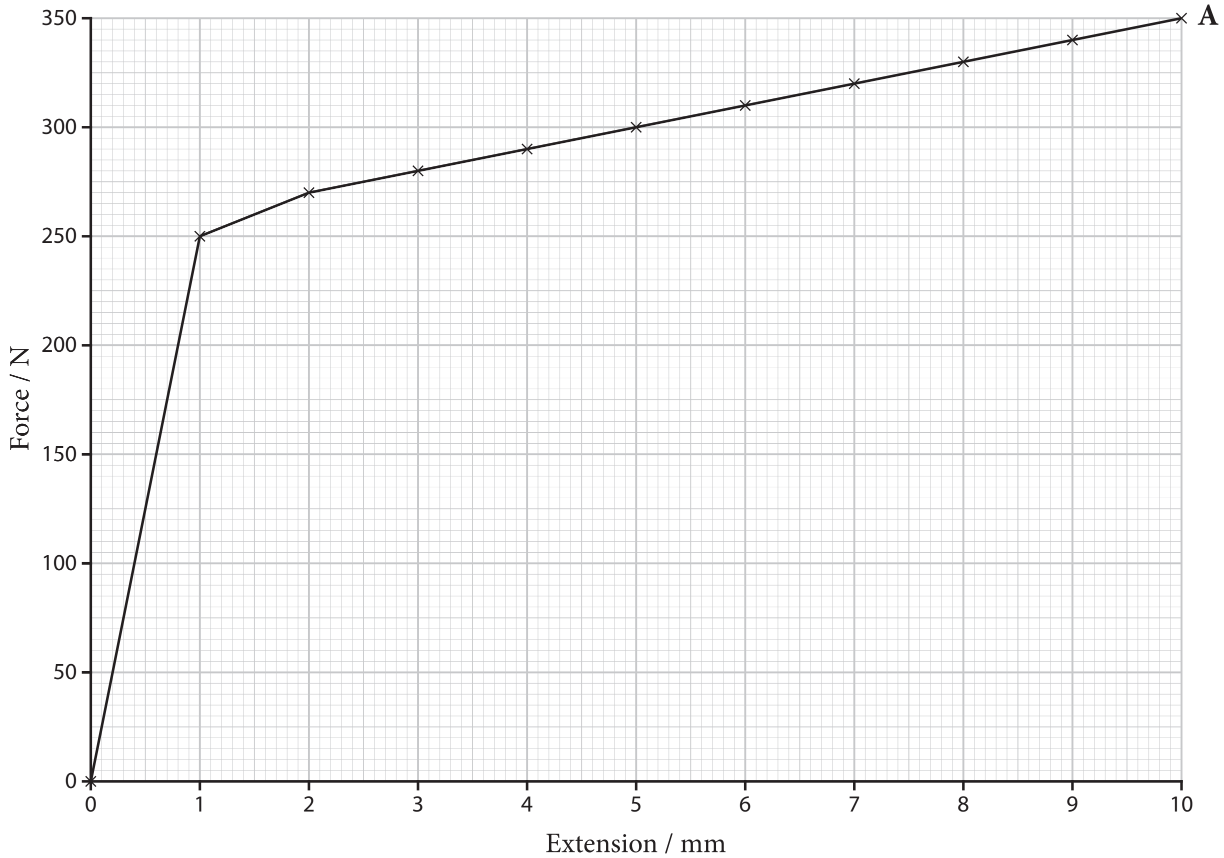
12. An aluminium wire has a length of 0.55 m and a diameter of 0.15 mm. It is stretched by 1.2 mm. The Young modulus of aluminium is 7.0×10^{10} Pa. Calculate:
    (a) the strain in the wire,
    (b) the stress in the wire,
    (c) the area of cross section of the wire,
    (d) the tension in the wire.

13. The graph on the right shows how the extension of a wire changed as increasing loads were placed on it. The original length of the wire was 5.0 m and its diameter was 4.0×10^{-4} m.

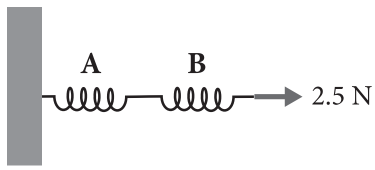
    Calculate:
    (a) the stress when the load is 40 N,
    (b) the energy stored in the wire when the load is 40 N,
    (c) the Young modulus of the material.



14. The force/extension graph for a wire is shown below.
The original length of the wire is 1.6 m and it has a diameter of 1.2 mm.
The wire broke at point **A** on the graph.
(a) Calculate the stress in the wire when the wire broke.
(b) Estimate the work done in stretching the wire until it broke.



15. Two spring are arranged as shown in the diagram on the right. The spring constant of wire A is 4 N mm^{-1}, and that of wire **B** is 5 N mm^{-1}. A stretching force of 2.5 N is applied as shown.
(a) By how much does each spring extend?
(b) Calculate the spring constant for the combination of springs.

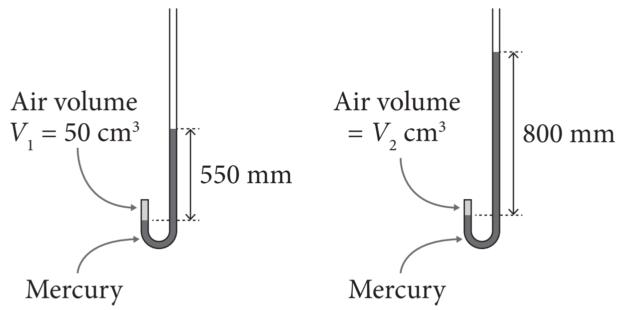


Unit 4.2 (A2 1)
Thermal Physics

1. Calculate the volume of 1 mol of any gas at STP.
   STP means a temperature of 273 K and a pressure of 1.01×10^5 Pa.

2. A container of molecular oxygen (O_2) at 50 °C and a pressure of 1.5×10^5 Pa has a volume of 6 m^3.
   Calculate the mass of oxygen in the container.
   1 mol of O_2 has a mass of 32 g.

3. An experiment to study the effect of pressure on the volume of a gas was carried out using the J-tube apparatus shown on the right. The atmospheric pressure was 1.01×10^5 Pa.



   The pressure due to a column of mercury is given by:
   pressure, $p = hrg$
   where:
   h = height of the mercury column, in m
   r = density of mercury, 13 600 kg m^{-3}
   g = acceleration of free fall, 9.81 m s^{-2}

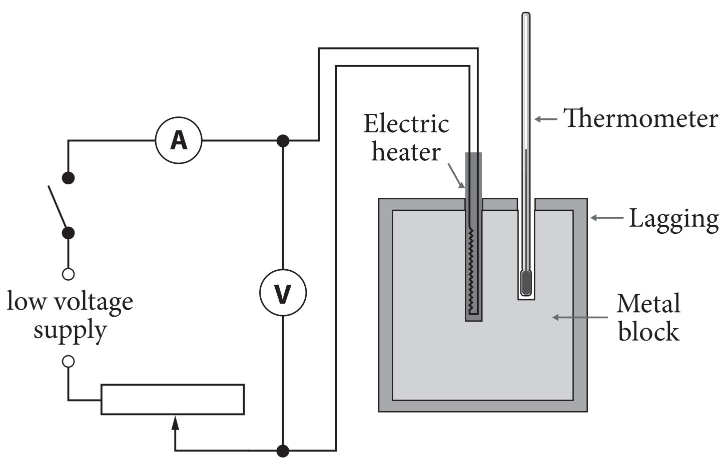
   The experiment is repeated for two heights of mercury, as shown. Calculate the volume V_2.

4. A container of volume 3.6×10^{-2} m^3 contains 2.5×10^{-2} kg of an ideal gas.
   The pressure in the container is 0.75×10^5 Pa and the temperature of the gas is 22 °C.
   (a) Calculate the number of gas molecules in the container.
   (b) Calculate the root mean square speed of the gas molecules.

5. Helium can be treated as an ideal gas. A sample of helium at 32 °C contains 2.5 mol of atoms.
   (a) What type of energy do the atoms of an ideal gas have?
   (b) Calculate the internal energy of the gas.

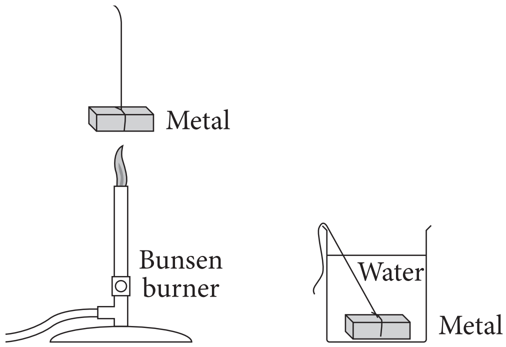
6. The apparatus shown on the right was used to measure the specific heat capacity of a metal.
   The following measurements were taken:

   Mass of the metal block = 1200 g
   Current = 2.5 A
   Voltage = 10.0 V
   Time the heater was on = 4 minutes
   Initial temperature of the metal = 18.5 °C
   Final temperature of the metal = 24.2 °C



   Calculate the specific heat capacity of the metal.

7. A metal is heated in a bunsen flame as shown on the right.
The metal is heated to a temperature of 600 °C.
It is then transferred to a beaker of water.
The following measurements were taken:



Mass of the metal = 0.5 kg
Mass of water in the beaker = 0.85 kg
Initial temperature of the water = 15 °C
Final temperature of the water and metal = 65 °C

The specific heat capacity of water = 4200 J kg^{-1} K^{-1}.
Calculate the specific heat capacity of the metal.

8. A gas has a pressure, p and a volume, V at a temperature of 20 °C. The pressure is tripled at a constant volume. What is the final temperature of the gas? Give your answer in kelvins.

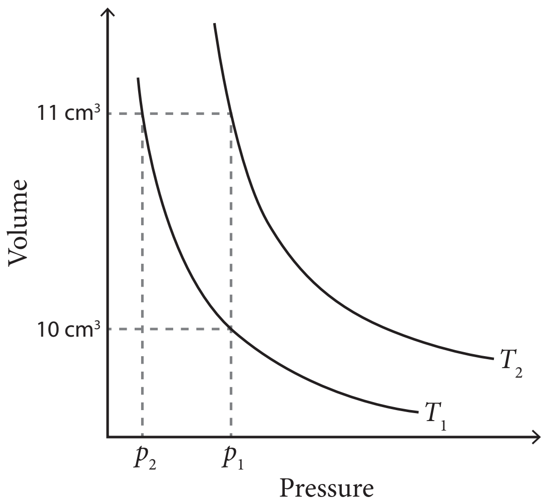
9. Using the kinetic theory, explain the following observations.
(a) When the volume of a gas is increased, the pressure it exerts decreases.
(b) When the temperature of a gas is increased, the pressure it exerts increases.
(c) When a gas is heated at constant pressure, it expands.

10. A car tyre is filled with air. The pressure gauge reads 210 kPa at 15 °C.
When driven for a time the temperature of the air rises to 40 °C.
Calculate the pressure of the air in the tyre now.

11. A Boyle's Law experiment was carried out at two different temperatures.
The same mass of gas was used in each case.
The graphs obtained are shown on the right.

Pressure $p_1 = 1.2\times10^5$ Pa.
Temperature $T_1 = 288$ K.

(a) Calculate the number of moles of gas used in the experiment.
(b) Calculate the temperature T_2.
(c) Calculate the pressure p_2.



12. What is the root mean square speed of air molecules of O_2 and N_2 at 18 °C?
The mass of an O_2 molecule is 5.34×10^{-26} kg and the mass of an N_2 molecule is 4.68×10^{-26} kg.

13. A balloon is inflated with helium at room temperature, 20 °C. When fully inflated, the balloon is a sphere of radius 20 cm and the pressure of helium inside is 1.2×10^5 Pa.
Calculate the mass of helium needed to fully inflate the balloon.
The mass of an He atom is 6.65×10^{-27} kg.

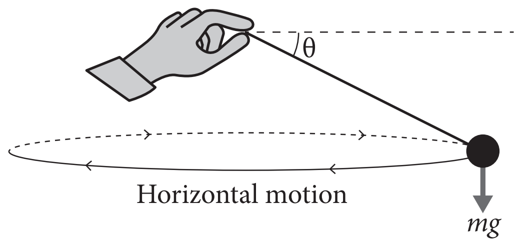
14. Show that for two gases at the same temperature, the ratio of their root mean square speeds is equal to the inverse of the square roots of their masses.

15. In interstellar space, the density of matter is about 1 hydrogen atom per cm^3.
The temperature in interstellar space is 2.7 K.
The mass of a hydrogen atom is 1.67×10^{-27} kg.
(a) Calculate the root mean square speed of the hydrogen atoms.
(b) Calculate the pressure of the interstellar gas.

Unit 4.3 (A2 1)
Uniform Circular Motion

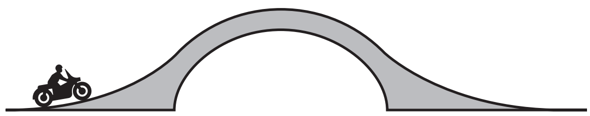
1. A washing machine is running a spin cycle with a value of 900 revolutions per minute (rpm).
   (a) Calculate the angular velocity of the washing machine drum.
   The diameter of the drum is 44 cm.
   (b) Calculate the velocity of a point on the edge of the drum.

2. An object of mass m is swung in a circle as shown on the right. The angular velocity of the object is ω and the radius of the circle is r. The tension in the string attached to the object is T.
   (a) Write down the relationship between the tension and the centripetal force.
   (b) Explain why the object can never be made to move in a horizontal circle.



3. The Moon's orbit around the Earth is almost circular with an average radius of 3.8×10^{8} m. The Moon's orbital period is 27.3 days, and its mass is 7.4×10^{22} kg.
   (a) Calculate the average angular velocity of the Moon.
   (b) Calculate the linear speed of the Moon as it orbits the Earth.
   (c) Calculate the magnitude of the centripetal force acting on the Moon.

4. A motorcyclist approaches a humpback bridge as shown. The radius of the bridge is 8 m.
   Calculate the maximum speed that the motorcyclist can pass over the bridge and still remain in contact with the road surface.



5. The diagram on the right shows a conical pendulum. The ball on the end of the string has a mass m and moves in a circle as shown.
   (a) Using the dimensions shown on the diagram calculate the value of the angle θ.
   (b) Write down an equation to show how the vertical component of the tension in the string, T, and the weight of the ball are related.
   (c) Write down an equation to show how the horizontal component of the tension in the string, T, and the centripetal force are related.
   (d) Using your answers to parts (b) and (c) calculate the angular velocity ω of the ball as it moves in its circular path.
   (e) Calculate the centripetal acceleration and tangential velocity of the ball.
   (f) Calculate how long it takes the ball to complete one revolution.
   (g) The ball has a mass of 0.5 kg. Calculate the tension, T, in the string.