Surname	Centre Number	Candidate Number
First name(s)		2

GCE AS/A LEVEL

2420U10-1

Z22-2420U10-1

WEDNESDAY, 18 MAY 2022 – MORNING

PHYSICS – AS unit 1
Motion, Energy and Matter

1 hour 30 minutes

For Examiner's use only		
Question	**Maximum Mark**	**Mark Awarded**
1.	**9**	
2.	**10**	
3.	**17**	
4.	**14**	
5.	**9**	
6.	**12**	
7.	**9**	
Total	**80**	

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ADDITIONAL MATERIALS

In addition to this paper you will require a calculator and a **Data Booklet**.

INSTRUCTIONS TO CANDIDATES

Use black ink or black ball-point pen. Do not use gel pen or correction fluid.
You may use a pencil for graphs and diagrams only.
Write your name, centre number and candidate number in the spaces at the top of this page.
Answer **all** questions.
Write your answers in the spaces provided in this booklet. If you run out of space use the additional page at the back of the booklet taking care to number the question(s) correctly.

INFORMATION FOR CANDIDATES

The total number of marks available for this paper is 80.
The number of marks is given in brackets at the end of each question or part-question.
The assessment of the quality of extended response (QER) will take place in question **5**(a).

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Answer **all** questions.

1. (a) State the conditions needed for a body to remain in equilibrium. [2]

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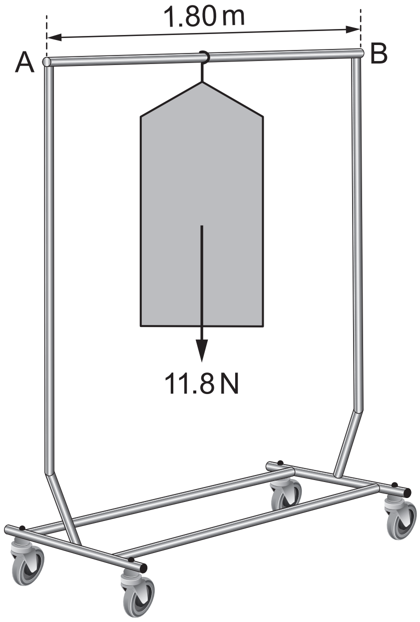
(b) The diagram shows a simple clothes carrier. It consists of a uniform horizontal beam (AB) of length 1.80 m resting on two vertical rods.



When the clothes carrier supports a coat weighing 11.8 N **at its centre**, a force of 8.0 N is exerted on each rod. Show that the weight, W, of the horizontal beam is approximately 4 N. [2]

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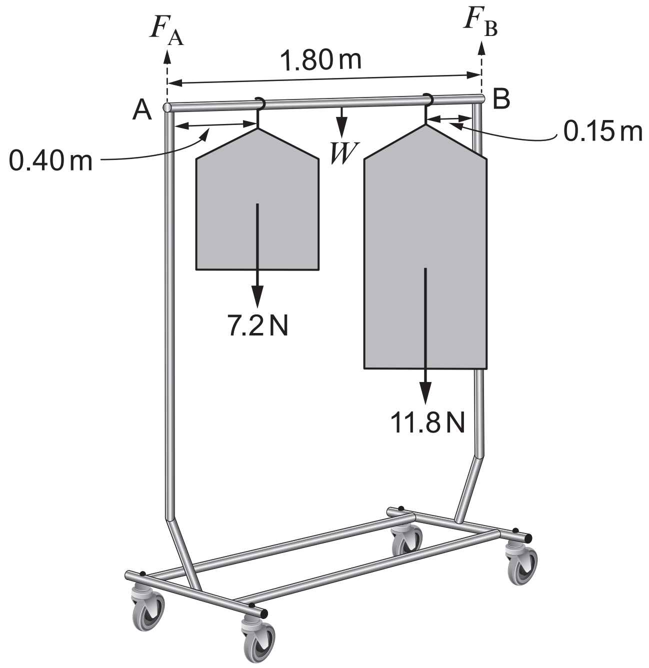
(c) The coat is now moved to a new position and a jacket weighing 7.2 N is hung from the beam, all of which is shown below.



Calculate forces F_A and F_B. [5]

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Turn over.

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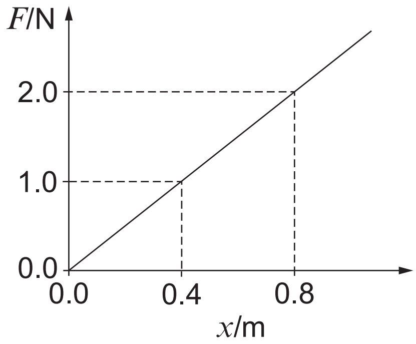
2. (a) The graph shows how the force, F, needed to stretch a simple spring varies with the extension, x, of the spring. The spring obeys Hooke's law.



(i) Calculate the work done in stretching the spring 0.4 m from its unstretched position. [2]

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(ii) Explain why the work done to stretch the spring 0.8 m from its unstretched position is **not twice** your answer to part (a)(i). [2]

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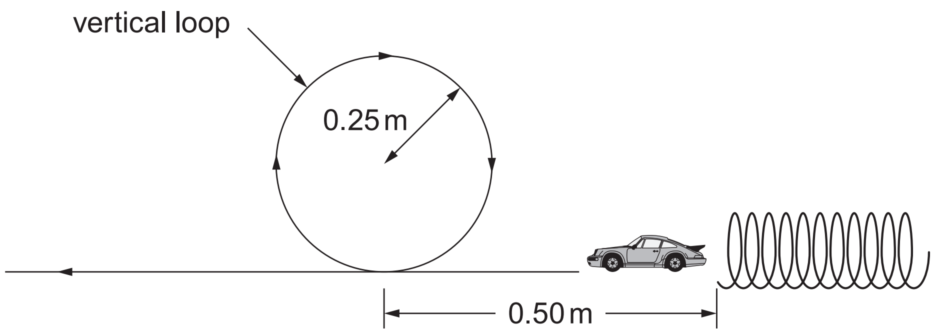
(b) The spring in part (a) is used to propel a toy car of mass 30 g along a track which contains a vertical loop of radius 0.25 m.



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(i) The spring is compressed by 0.4 m. The car is placed against the end of the spring, which is then released. Assuming that all of the spring's energy is transferred to the car and that no resistive forces act on it, calculate the speed of the car at the top of the loop. [3]

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(ii) In reality resistive forces act on the car to the extent that the car loses 5% of its initial energy to frictional forces in moving from the spring to the top of the loop. Calculate the mean resistive force acting on the car during this motion. [3]

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3. Drones such as the one shown in the picture have an increasing number of uses in society. This question considers some of the Physics associated with drones.

(a) (i) State Newton's third law of motion. [1]

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(ii) The drone in the picture has four rotors and is shown hovering stationary in the air. The table describes two vertical forces acting on the drone. According to Newton's third law each of these forces is part of a pair of forces. Identify the other force in each case. [2]

Forces acting vertically downwards	Forces acting vertically upwards
Gravitational force of Earth on drone	....
....	Force of air on rotors

(b) The drone is able to hover when each rotor produces a downward flow of air of speed $22\,\mathrm{m\,s^{-1}}$. The momentum given to the air by the 4 rotors produces an upward force which keeps the drone stationary in the air.

(i) State the relationship between force and momentum. [1]

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(ii) The rate of change of momentum of the air **from the 4 rotors** can be expressed as:

$$4\pi r^2 \rho v^2$$

where r is the radius of each of the rotor blades, v is the speed of the air which is set in motion and ρ is the density of the air. Use this expression to show that the weight of the drone is approximately 20 N. [ρ = 1.3 kg m^{-3}, r = 5.0 × 10^{-2} m] [2]

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(iii) Calculate the vertical acceleration of the drone when v is increased to 24 m s^{-1}. [4]

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(c) (i) Define *velocity*. [1]

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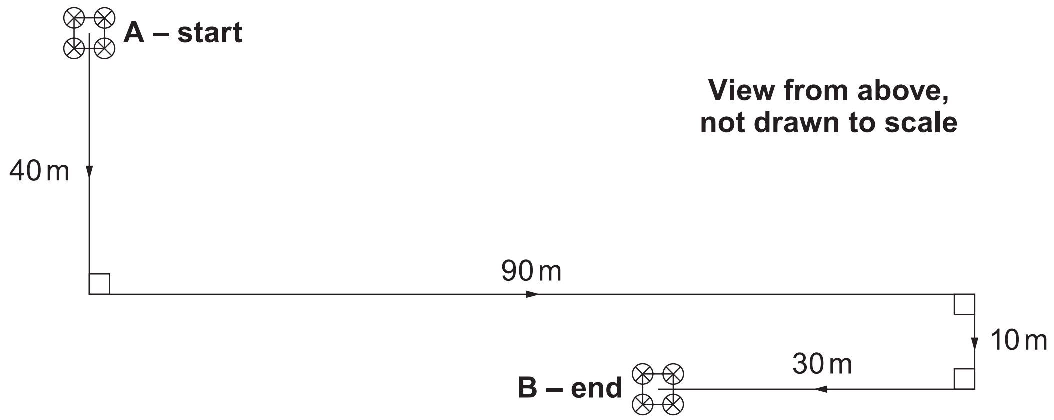
(ii) Bill flies the drone from **A** to **B** in a time of 32 s along the path shown below. The drone is kept at the same height above the ground for the entire flight.



Bill's friend Ted believes that, in flying this path (from **A** to **B**), the mean speed of the drone is more than twice the magnitude of its mean velocity. Bill disagrees. Use the information given to determine who is correct. [4]

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(d) Drones have many applications in today's society. Give **one** benefit and **one** risk of drone technology. [2]

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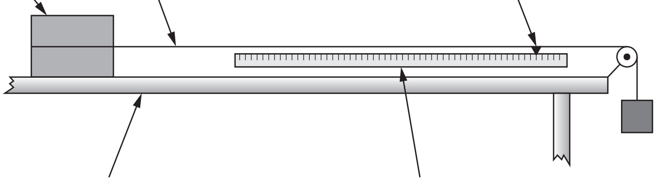
4. Karen is an A level Physics student who has been absent for some of her Physics practical lessons. During her absence, the other students in the class have been using the apparatus below to identify the metal in a wire by finding the Young modulus of the metal and comparing it with known values.



In order to catch up with the other students, Karen decides to use the same apparatus to carry out a quick experiment to find the Young modulus. Her notes are shown in the box below.

- Take single reading of diameter using a micrometer of resolution 0.01 mm.
  Diameter = 0.18 mm
- Use a metre ruler of resolution 1 mm to measure the initial length of the wire.
  Initial length = 1.940 m
- Set up the apparatus and add a **mass of 1.0 kg** to the end of the wire.
  Measure extension.
  Extension = 6.0 ± 0.5 mm

(a) Use Karen's notes to answer the following questions.

(i) Calculate the cross-sectional area of the wire **in m^2** and show that the **percentage** uncertainty in its value is approximately 11%. [2]

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(ii) Show, with an appropriate calculation, that the uncertainty in the length reading can be considered negligible. [1]

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(b) (i) Determine the Young modulus of the metal. [2]

(ii) Karen is told by her teacher that the percentage uncertainty in the load is 5%. Use this information along with Karen's notes and your answers to (a) to calculate the **absolute** uncertainty in the Young modulus. Give your answer in GPa and to an appropriate number of significant figures. [4]

(c) The following table shows Young modulus values of the wires available to the students.

Metal	Young modulus / GPa
aluminium	70
zinc	100
bronze	103
copper	117
nickel	166

Karen's friend Jack determined the Young modulus of the metal to be 126 ± 20 GPa. They both use the above table to determine the metal in their wires. Discuss how Jack's conclusions differ from Karen's. [2]

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(d) Jack had more time to carry out this experiment than Karen. Suggest differences in the way Jack carried out the experiment (i.e. procedure) **and** in the way that he analysed his results which led to him reaching a different conclusion to Karen. [3]

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5. (a) **Hadrons** are a group of particles. Write a detailed account of hadrons, including how they may be subdivided into other groups of particles, giving examples. [6 QER]

(b) A high energy interaction between a proton and a pion is shown below.

$$p + \pi^- \rightarrow n + \pi^+ + \pi^-$$

Use conservation laws to show that the interaction is possible. [3]

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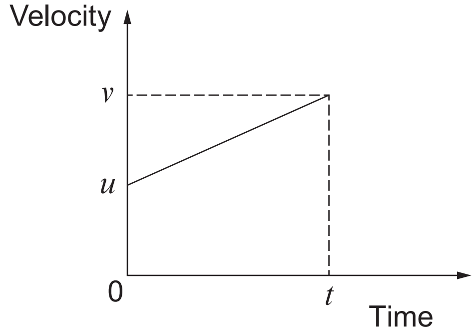
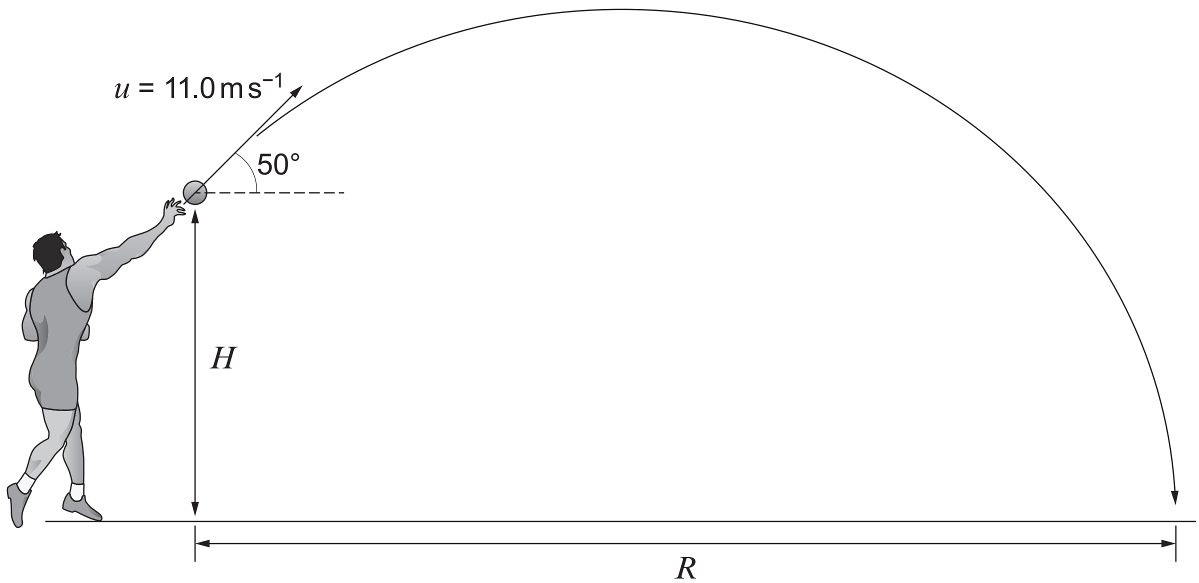
6. (a) A velocity-time graph is given for a body which is accelerating uniformly for a time, t.



Using the graph, show clearly that: [3]

$$x = ut + \tfrac{1}{2}at^2$$

(b) The shot put is an event in athletics. The shot (a heavy metal ball) is thrown from a standing position so that it lands on the ground a horizontal distance, R, from the thrower.



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Steve is a shot putter. He throws a shot with a velocity of $11.0\,\text{m}\,\text{s}^{-1}$ in a direction 50° to the horizontal. The shot takes 1.95 s to reach the ground.

(i) Show that the vertical component of the initial velocity is approximately $8\,\text{m}\,\text{s}^{-1}$. [1]

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(ii) Hence calculate, H, the vertical distance above the ground from which the shot was thrown. [3]

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(iii) Calculate the horizontal distance, R, for this throw. [2]

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(c) Steve makes the following comment to Bryn, a fellow competitor.

"Throwing the shot at an angle even greater than 50° to the horizontal will increase the horizontal distance travelled by the shot because the time of flight will increase."

Consider whether or not it would be a good idea for Bryn to follow Steve's advice. Justify your answer. [3]

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7. (a) Stars are very good approximations of *black bodies*. Explain what is meant by the term *black body*. [1]

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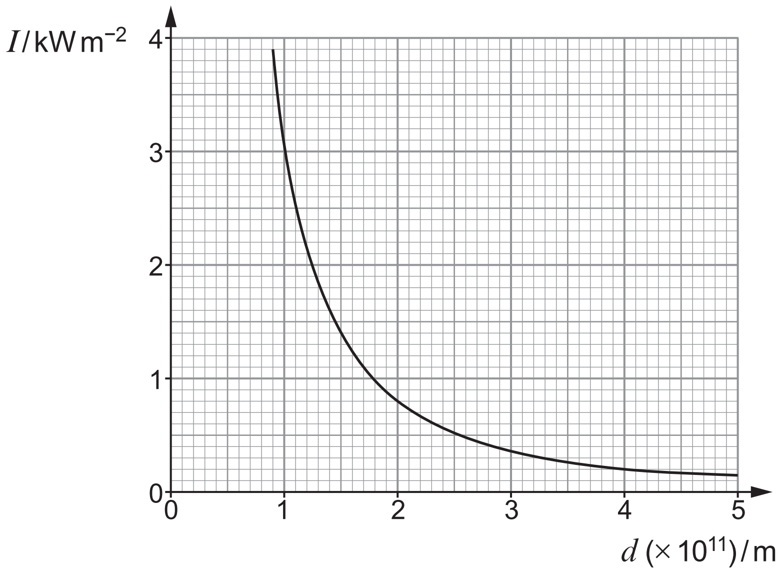
(b) The graph shows how the intensity of electromagnetic radiation, I, from the Sun varies with the distance from its centre, d.



(i) Confirm that the graph shows an inverse square relationship between I and d. [2]

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(ii) Show that the Sun's luminosity is approximately 4×10^{26} W. [2]

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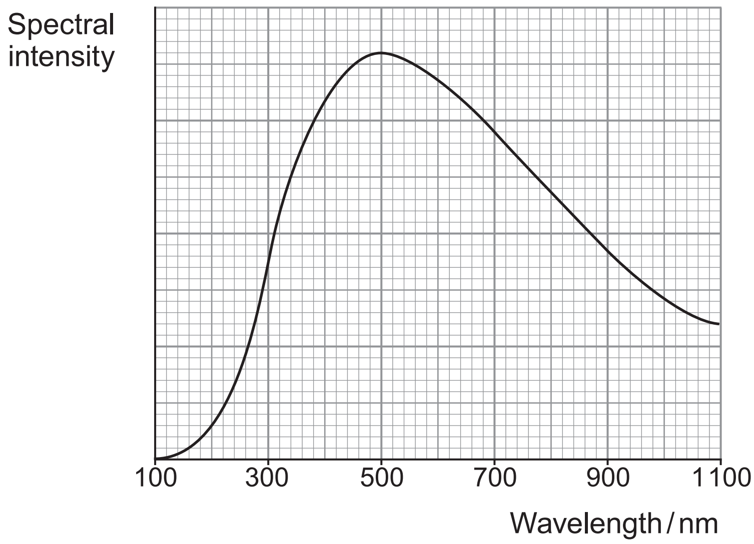
(c) The graph shows how the intensity of the radiation incident on the Earth from the Sun is distributed across the spectrum.



Use information from this graph, along with your answer to (b)(ii), to calculate the radius of the Sun. [4]

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Question number	Additional page, if required. Write the question number(s) in the left-hand margin.

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