Centre Number						Candidate Number				
Surname										
Other Names										
Candidate Signature										

For Examiner's Use	
Examiner's Initials	
Question	Mark
1	
2	
3	
4	
5	
6	
7	
TOTAL	

General Certificate of Education
Advanced Subsidiary Examination
January 2012

Physics A PHYA2

Unit 2 Mechanics, Materials and Waves

Friday 20 January 2012 9.00 am to 10.15 am

For this paper you must have:
- a pencil and a ruler
- a calculator
- a Data and Formulae Booklet (enclosed).

Time allowed
- 1 hour 15 minutes

Instructions
- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Do not write outside the box around each page or on a blank page.
- Do all rough work in this book. Cross through any work you do not want to be marked.
- Show all your working.

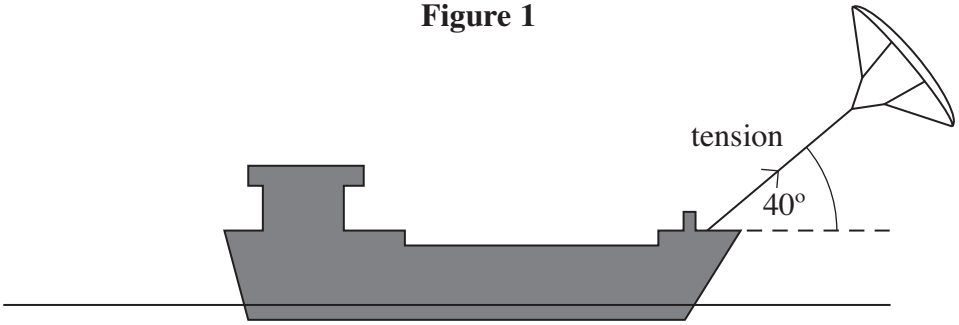
Information
- The marks for questions are shown in brackets.
- The maximum mark for this paper is 70.
- You are expected to use a calculator where appropriate.
- A *Data and Formulae Booklet* is provided as a loose insert.
- You will be marked on your ability to:
  – use good English
  – organise information clearly
  – use specialist vocabulary where appropriate.

Do not write outside the box

Answer **all** questions in the spaces provided.

1 Sail systems are being developed to reduce the running costs of cargo ships. The sail and ship's engines work together to power the ship. One of these sails is shown in **Figure 1** pulling at an angle of 40° to the horizontal.

Figure 1



1 (a) The average tension in the cable is 170 kN.
Show that, when the ship travels 1.0 km, the work done by the sail on the ship is 1.3×10^8 J.

(2 marks)

1 (b) With the sail and the engines operating, the ship is travelling at a steady speed of 7.0 m s^{-1}.

1 (b) (i) Calculate the power developed by the sail.

answer = ... W
(2 marks)

Do not write outside the box

1 (b) (ii) Calculate the percentage of the ship's power requirement that is provided by the wind when the ship is travelling at this speed.
The power output of the engines is 2.1 MW.

answer = ... %
(2 marks)

1 (c) The angle of the cable to the horizontal is one of the factors that affects the horizontal force exerted by the sail on the ship. State **two** other factors that would affect this force.

Factor 1 .....

Factor 2 .....
(2 marks)

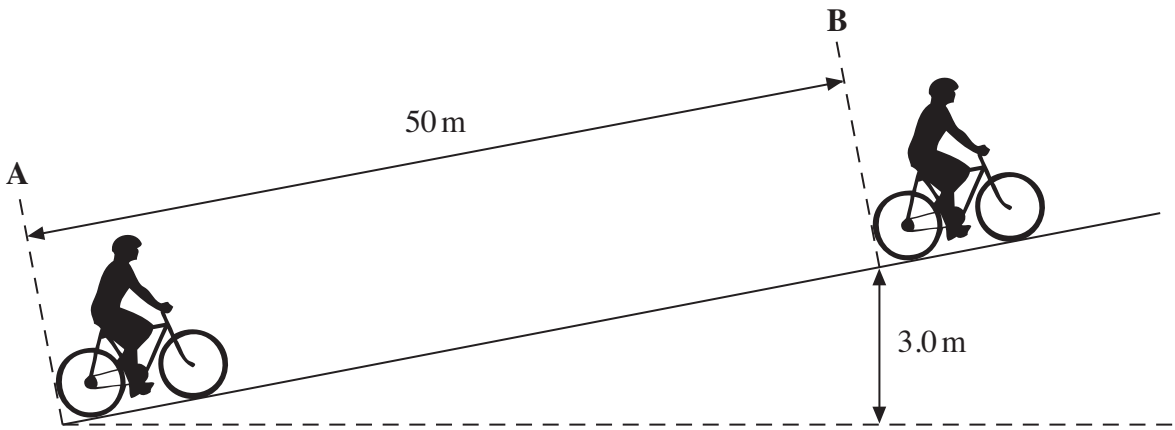
8

Turn over for the next question

Do not write outside the box

2 An 'E-bike' is a bicycle that is assisted by an electric motor. **Figure 2** shows an E-bike and rider with a total mass of 83 kg moving up an incline.

Figure 2



2 (a) (i) The cyclist begins at rest at **A** and accelerates uniformly to a speed of 6.7 m s^{-1} at **B**. The distance between **A** and **B** is 50 m.
Calculate the time taken for the cyclist to travel this distance.

answer = ... s
(2 marks)

2 (a) (ii) Calculate the kinetic energy of the E-bike and rider when at **B**. Give your answer to an appropriate number of significant figures.

answer = ... J
(2 marks)

Do not write outside the box

2 (a) (iii) Calculate the gravitational potential energy gained by the E-bike and rider between **A** and **B**.

answer = ... J
(2 marks)

2 (b) Between **A** and **B**, the work done by the electric motor is 3700 J, and the work done by the cyclist pedalling is 5300 J.

2 (b) (i) Calculate the wasted energy as the cyclist travels from **A** to **B**.

answer = ... J
(2 marks)

2 (b) (ii) State **two** causes of this wasted energy.

Cause 1 .....

.....

Cause 2 .....

.....
(2 marks)

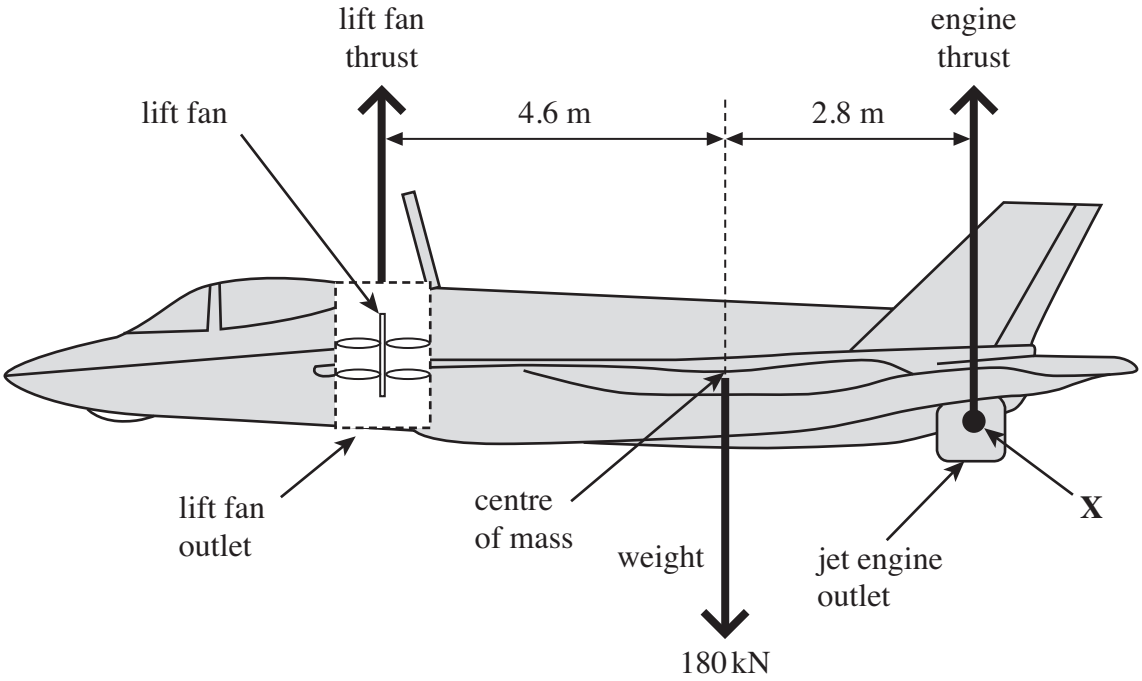
10

Turn over for the next question

Do not write outside the box

3 **Figure 3** shows an aircraft designed to take off and land vertically and also to hover without horizontal movement. In order to achieve this, upward lift is produced by directing the jet engine outlet downwards. The engine also drives a vertical lift fan near the front of the aircraft. The weight of the aircraft is 180 kN. The distance between the lift fan and the centre of mass is 4.6 m and the distance between the jet engine outlet and the centre of mass is 2.8 m.

Figure 3



3 (a) (i) Calculate the moment caused by the weight of the aircraft about the point **X**.

answer = ... N m
(2 marks)

3 (a) (ii) By taking moments about **X**, calculate the lift fan thrust if the aircraft is to remain horizontal when hovering.

answer = ... N
(3 marks)

Do not write outside the box

3 (a) (iii) Calculate the engine thrust in **Figure 3**.

answer = ... N
(1 mark)

3 (b) Having taken off vertically, the jet engine outlet is turned so that the engine thrust acts horizontally. The aircraft accelerates horizontally to a maximum velocity. The forward thrust produced by the jet is 155 kN. The weight of the aircraft is 180 kN.

3 (b) (i) When the resultant horizontal force is 155 kN, calculate the horizontal acceleration of the aircraft.

answer = ... $m\,s^{-2}$
(2 marks)

3 (b) (ii) State and explain **one** characteristic of the aircraft that limits its maximum horizontal velocity.

.....

.....

.....

.....
(2 marks)

Question 3 continues on the next page

Do not write outside the box

3 (b) (iii) On the axes below, sketch the velocity-time graph for the horizontal motion of the aircraft as it accelerates from zero to its maximum horizontal velocity.



(2 marks)

3 (c) State how a velocity-time graph could be used to find the maximum acceleration.

.....

(1 mark)

13

Turn to page 10 for the next question

Do not write outside the box

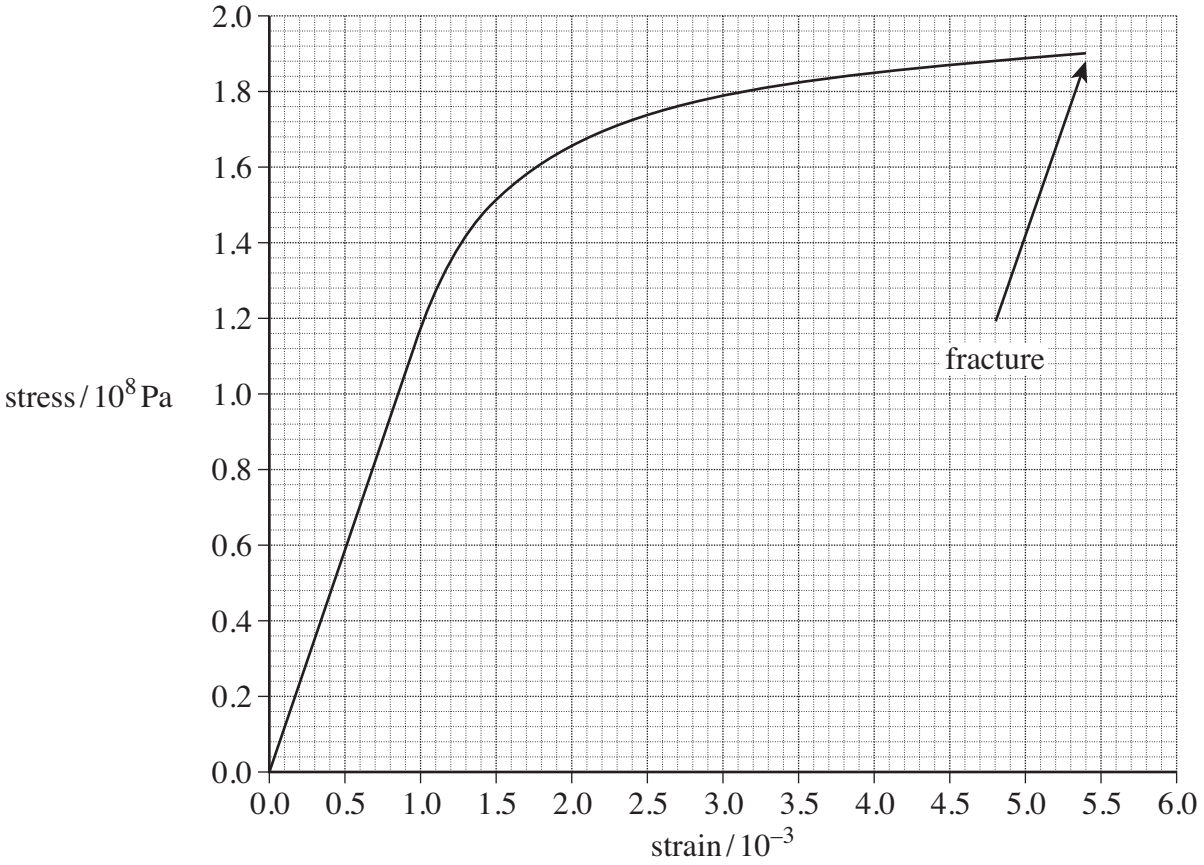
There are no questions printed on this page

DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED

Do not write outside the box

4 **Figure 4** shows a stress-strain graph for a copper wire.

Figure 4



4 (a) Define tensile strain.

.....

.....

(1 mark)

4 (b) State the breaking stress of this copper wire.

answer = ... Pa

(1 mark)

4 (c) Mark on **Figure 4** a point on the line where you consider plastic deformation may start. Label this point **A**.

(1 mark)

4 (d) Use the graph to calculate the Young modulus of copper. State an appropriate unit for your answer.

answer = ...

(3 marks)

Do not write outside the box

4 (e) The area under the line in a stress-strain graph represents the work done per unit volume to stretch the wire.

4 (e) (i) Use the graph to find the work done per unit volume in stretching the wire to a strain of 3.0×10^{-3}.

answer = ... J m^{-3}

(2 marks)

4 (e) (ii) Calculate the work done to stretch a 0.015 kg sample of this wire to a strain of 3.0×10^{-3}.

The density of copper = 8960 kg m^{-3}.

answer = ... J

(2 marks)

4 (f) A certain material has a Young modulus greater than copper and undergoes brittle fracture at a stress of 176 MPa.

On **Figure 4** draw a line showing the possible variation of stress with strain for this material.

(2 marks)

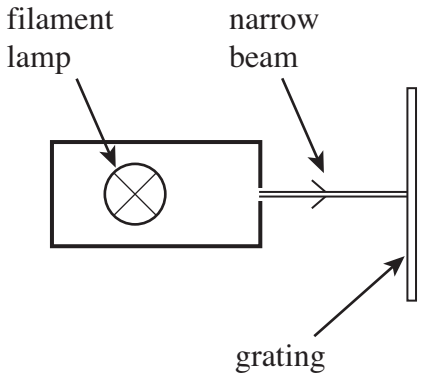
12

Turn over for the next question

Do not write outside the box

5 (a) In an experiment, a narrow beam of white light from a filament lamp is directed at normal incidence at a diffraction grating. Complete the diagram in **Figure 5** to show the light beams transmitted by the grating, showing the zero-order beam and the first-order beams.

Figure 5



(3 marks)

5 (b) Light from a star is passed through the grating.

Explain how the appearance of the first-order beam can be used to deduce **one** piece of information about the gases that make up the outer layers of the star.

.....

.....

.....

.....

(2 marks)

5 (c) In an experiment, a laser is used with a diffraction grating of known number of lines per mm to measure the wavelength of the laser light.

5 (c) (i) Draw a labelled diagram of a suitable arrangement to carry out this experiment.

(2 marks)

Do not write outside the box

5 (c) (ii) Describe the necessary procedure in order to obtain an accurate and reliable value for the wavelength of the laser light.
Your answer should include details of all the measurements and necessary calculations.
The quality of your written communication will be assessed in your answer.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

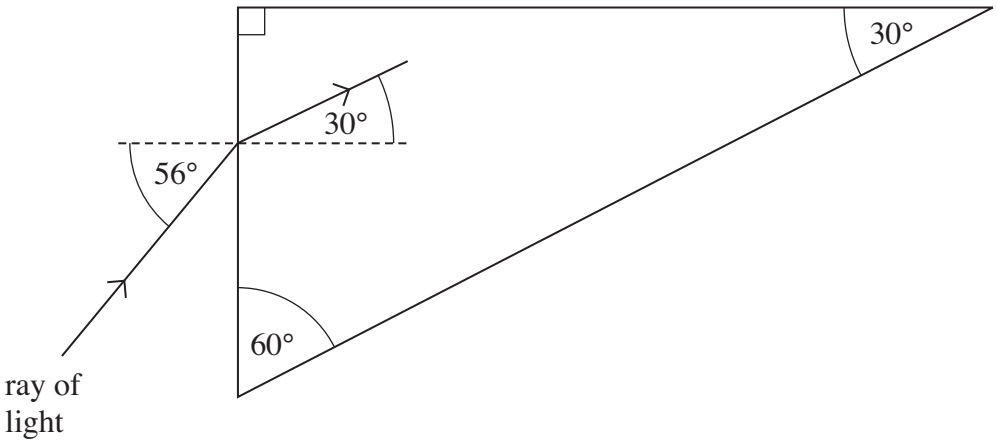
(6 marks)

13

Do not write outside the box

6 **Figure 6** shows a glass prism. Light is directed into the prism at an angle of 56°. The path of the ray of light is shown as is it enters the prism.

Figure 6



6 (a) (i) Calculate the refractive index of the glass.

answer = ...

(2 marks)

6 (a) (ii) Calculate the critical angle for the glass-air boundary.

answer = ... degrees

(2 marks)

6 (b) On **Figure 6**, continue the path of the ray of light until it emerges from the prism.

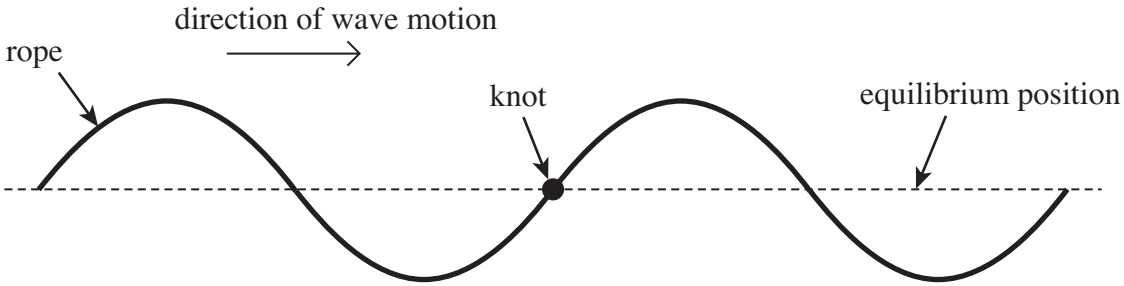
(2 marks)

6

Do not write outside the box

7 **Figure 7** shows a continuous progressive wave on a rope. There is a knot in the rope.

Figure 7



7 (a) Define the amplitude of a wave.

.....

.....

(2 marks)

7 (b) The wave travels to the right.
Describe how the **vertical** displacement of the knot varies over the next complete cycle.

.....

.....

.....

.....

.....

(3 marks)

7 (c) A continuous wave of the same amplitude and frequency moves along the rope from the right and passes through the first wave. The knot becomes motionless.
Explain how this could happen.

.....

.....

.....

.....

.....

.....

(3 marks)

END OF QUESTIONS

8

There are no questions printed on this page

DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED

Copyright © 2012 AQA and its licensors. All rights reserved.