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
June 2011

Physics A PHYA2

Unit 2 Mechanics, Materials and Waves

Monday 6 June 2011 1.30 pm to 2.45 pm

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

Time allowed
- 1 hour 15 minutes

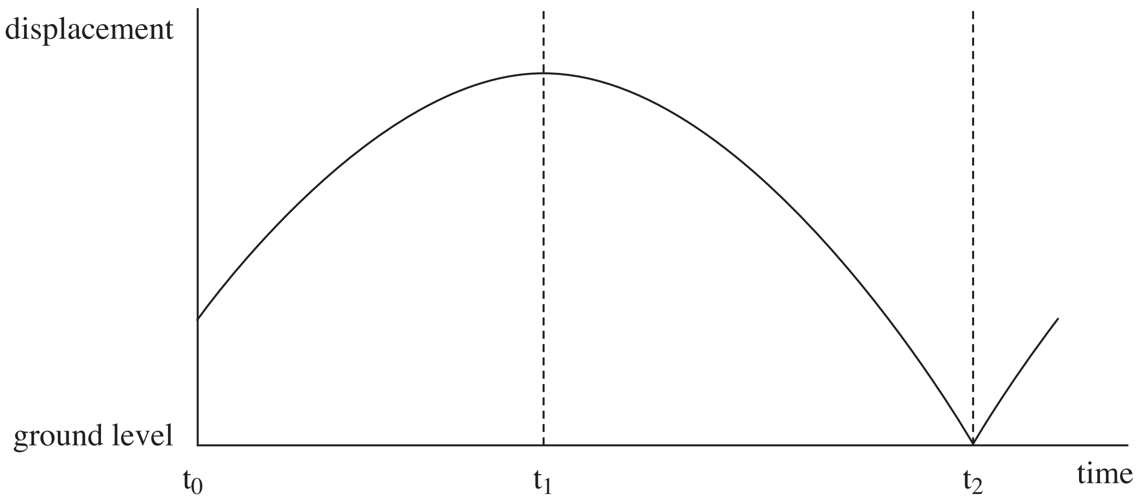
Instructions
- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Do not write outside the box around each page or on blank pages.
- Do all rough work in this book. Cross through any work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

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.

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

1 A boy throws a ball vertically upwards and lets it fall to the ground. **Figure 1** shows how displacement relative to the ground varies with time for the ball.

Figure 1



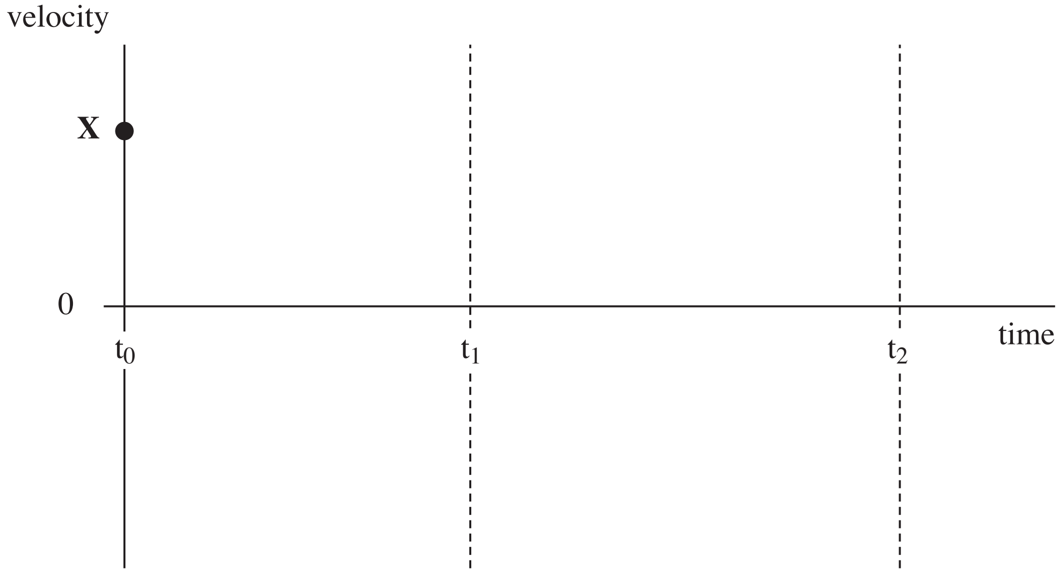
1 (a) (i) State which feature of a displacement-time graph represents the velocity.

....

(1 mark)

1 (a) (ii) On the axes below, draw the shape of the velocity-time graph for the ball between t_0 and t_2. The starting point is labelled **X**.

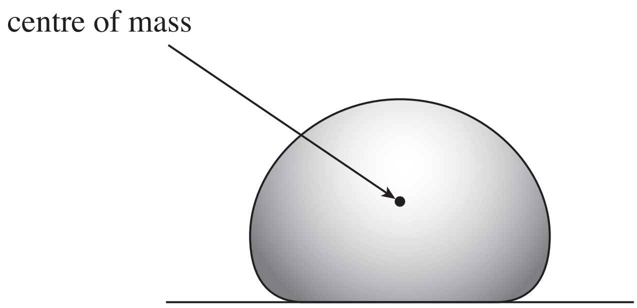
(3 marks)



Do not write outside the box

1 (b) **Figure 2** shows the ball deforming as it contacts the ground, just at the point where it is stationary for an instant and has reached maximum deformation.

Figure 2



1 (b) (i) Explain how Newton's third law of motion applies to **Figure 2**.

....

....

....

....

(2 marks)

1 (b) (ii) Explain why there is a resultant upward force on the ball in **Figure 2**.

....

....

....

....

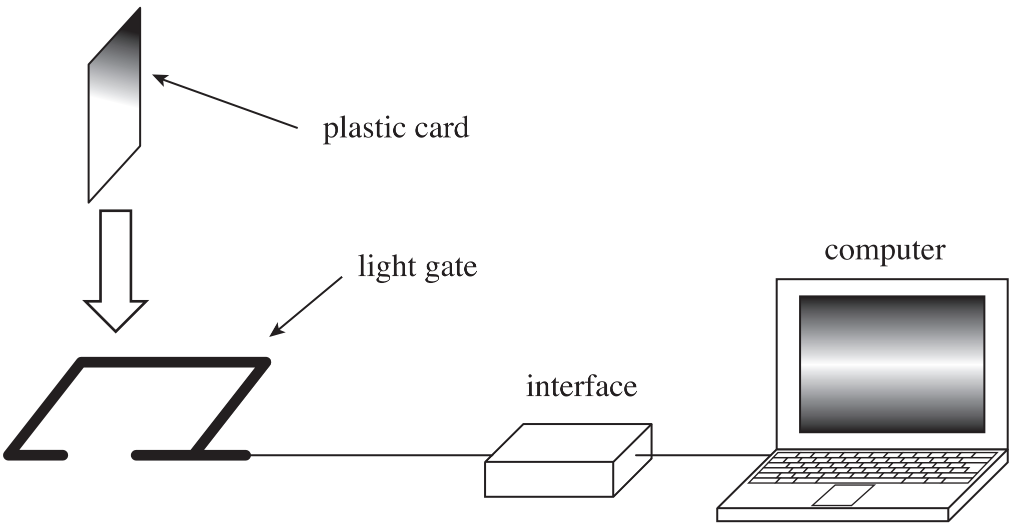
(2 marks)

8

Turn over for the next question

2 A student measures the acceleration due to gravity, g, using the apparatus shown in **Figure 3**. A plastic card of known length is released from rest at a height of 0.50 m above a light gate. A computer calculates the velocity of the card at this point, using the time for the card to pass through the light gate.

Figure 3



2 (a) The computer calculated a value of $3.10\,\mathrm{m\,s^{-1}}$ for the velocity of the card as it travelled through the light gate. Calculate a value for the acceleration due to gravity, g, from these data.

answer = ... $\mathrm{m\,s^{-2}}$

(2 marks)

2 (b) The student doubles the mass of the card and finds a value for g that is similar to the original value. Use the relationship between *weight*, *mass* and g to explain this result.

....

....

....

....

(1 mark)

Do not write outside the box

2 (c) State and explain **one** reason why the card would give more reliable results than a table tennis ball for this experiment.

....

....

....

....

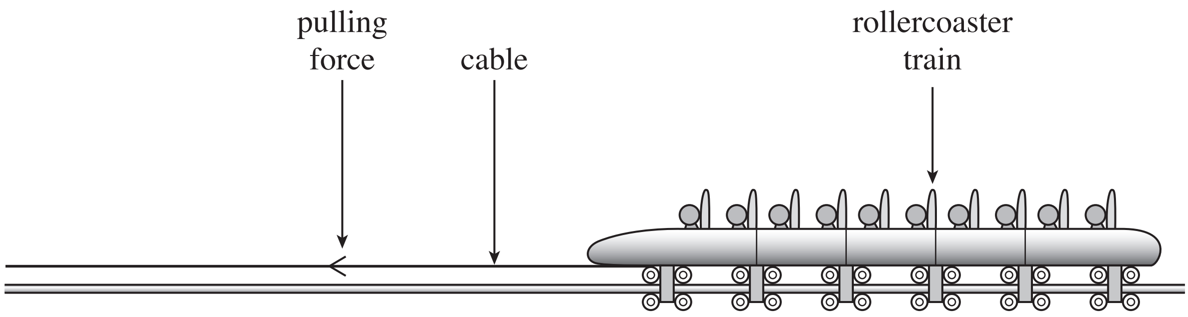
(2 marks)

5

Turn over for the next question

3 **Figure 4** shows a rollercoaster train that is being accelerated when it is pulled horizontally by a cable.

Figure 4



3 (a) The train accelerates from rest to a speed of $58\,\text{ms}^{-1}$ in 3.5 s. The mass of the fully loaded train is 5800 kg.

3 (a) (i) Calculate the average acceleration of the train.

answer = ... ms^{-2}
(2 marks)

3 (a) (ii) Calculate the average tension in the cable as the train is accelerated, stating an appropriate unit.

answer = ...
(3 marks)

Do not write outside the box

3 (a) (iii) Calculate the distance the train moves while accelerating from rest to $58\,\text{m}\,\text{s}^{-1}$.

answer = ... m
(2 marks)

3 (a) (iv) The efficiency of the rollercoaster acceleration system is 20%.
Calculate the average power input to this system during the acceleration.

answer = ... W
(3 marks)

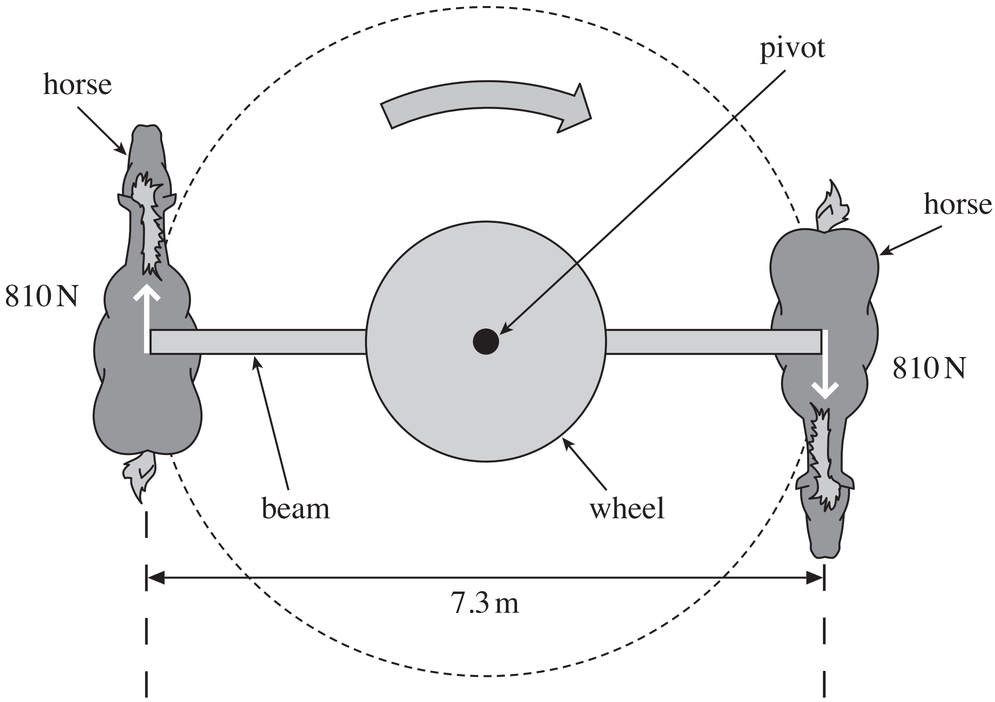
3 (b) After reaching its top speed the driving force is removed and the rollercoaster train begins to ascend a steep track. By considering energy transfers, calculate the height that the train would reach if there were no energy losses due to friction.

answer = ... m
(3 marks)

13

4 Horses were once used to power machinery in factories, mines and mills.
Figure 5 shows two horses attached to a beam which turns a wheel. This wheel drives machinery.

Figure 5



4 (a) Each horse exerts a force of 810 N and the length of the beam is 7.3 m.

4 (a) (i) Define the moment of a couple.

....

....

....
(2 marks)

4 (a) (ii) Calculate the moment of the couple exerted by the horses, stating an appropriate unit.

answer = ...
(2 marks)

Do not write outside the box

4 (b) The horses move at a constant speed of $0.91\,\mathrm{m\,s^{-1}}$. Calculate the combined power output of the two horses. Give your answer to an appropriate number of significant figures.

answer = ... W

(3 marks)

4 (c) During the Industrial Revolution in the 19th Century, James Watt became well known for developing and improving steam engines to replace horses. He defined the unit of power called '*horsepower*' by studying a system similar to the one shown in **Figure 5**.

Suggest why Watt decided to use *horsepower* as a unit of power.

....

....

....

(1 mark)

8

Turn over for the next question

Do not write outside the box

5 (a) The speed of light is given by

$$c = f\lambda$$

State how each of these quantities will change, if at all, when light travels from air to glass.

c ....

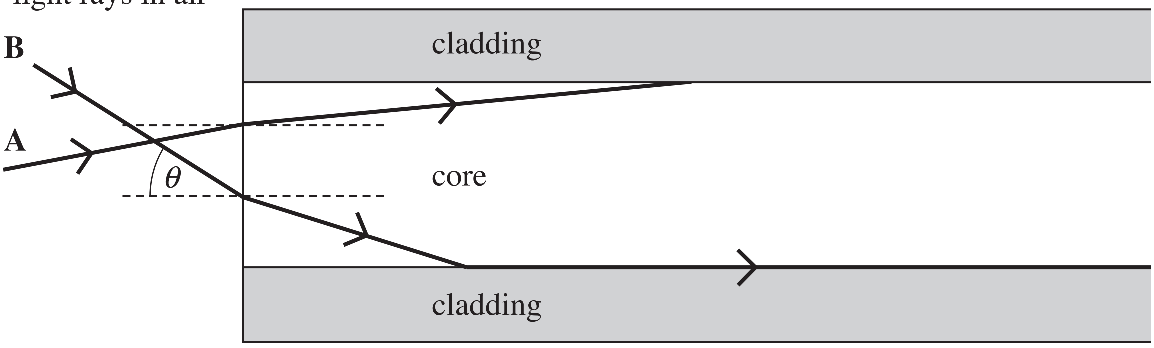
f ....

λ ....

(3 marks)

Figure 6 shows a side view of a step index optical fibre.

Figure 6



5 (b) Ray **A** enters the end of the fibre and then undergoes total internal reflection. On **Figure 6** complete the path of this ray along the fibre.

(2 marks)

5 (c) (i) The speed of light in the core is 2.04×10^{8} ms^{-1}. Show that the refractive index of the core is 1.47.

(2 marks)

5 (c) (ii) Show that the critical angle at the boundary between the core and the cladding is about 80°.

refractive index of the cladding = 1.45

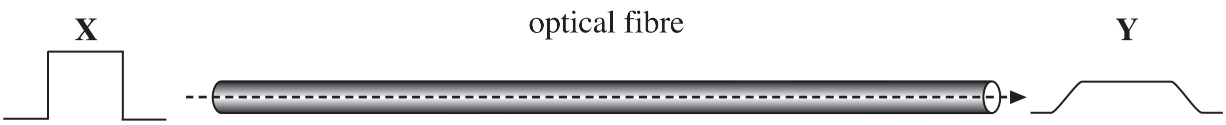
(2 marks)

5 (d) Ray **B** enters the end of the fibre and refracts along the core-cladding boundary. Calculate the angle of incidence, θ, of this ray at the point of entry to the fibre.

answer = ... degrees
(3 marks)

5 (e) **Figure 7** shows a pulse of monochromatic light (labelled **X**) that is transmitted a significant distance along the fibre. The shape of the pulse after travelling along the fibre is labelled **Y**. Explain why the pulse at **Y** has a lower amplitude and is longer than it is at **X**.

Figure 7



....

....

....

....
(2 marks)

14

Do not write outside the box

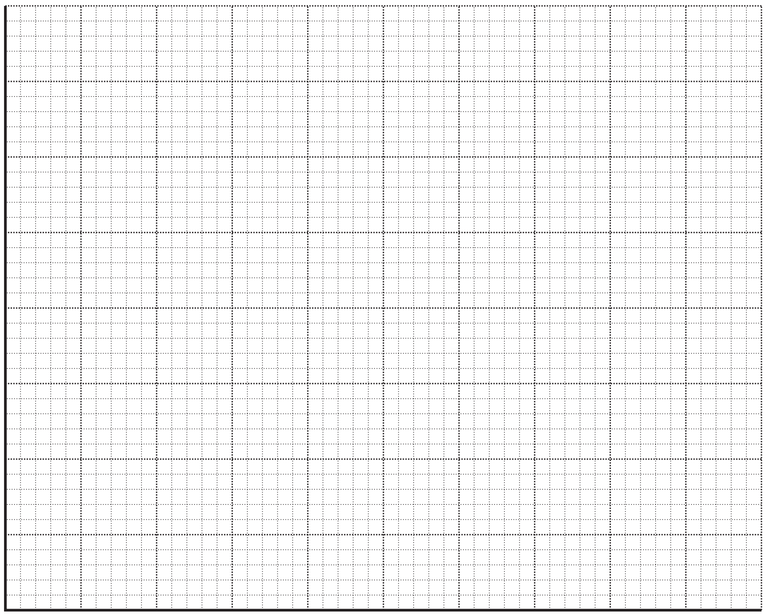
6 The table below shows the results of an experiment where a force was applied to a sample of metal.

6 (a) On the axes below, plot a graph of stress against strain using the data in the table.

(3 marks)

strain / 10^{-3}	0	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00
stress / 10^{8} Pa	0	0.90	2.15	3.15	3.35	3.20	3.30	3.50	3.60	3.60	3.50

stress / 10^8 Pa



strain / 10^{-3}

6 (b) Use your graph to find the Young modulus of the metal.

answer = ... Pa

(2 marks)

Do not write outside the box

6 (c) A 3.0 m length of steel rod is going to be used in the construction of a bridge. The tension in the rod will be 10 kN and the rod must extend by no more than 1.0 mm. Calculate the minimum cross-sectional area required for the rod.

Young modulus of steel = 1.90×10^{11} Pa

answer = ... m^2

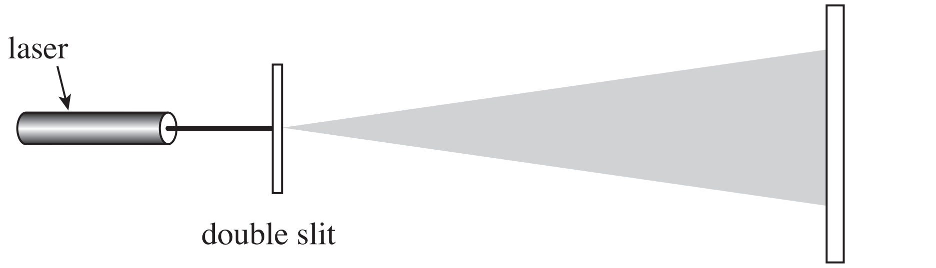
(3 marks)

8

Turn over for the next question

7 A scientist is going to use a double-slit arrangement to carry out measurements in order to determine the wavelength of light from a laser.

Figure 8



7 (a) The scientist has a double slit of known separation. Describe the measurements that need to be taken and explain how they are used to find the wavelength of the light. Discuss any necessary safety precautions and how you would arrange the apparatus to improve accuracy.

The quality of your written communication will be assessed in this question.

....

....

....

....

....

....

....

....

....

....

....

....

....

....

....

....

(6 marks)

7 (b) In 1802 Thomas Young used candle light to observe the interference pattern from two narrow slits acting as *coherent light sources*.

Explain what is meant by coherent light sources.

....

....

....

(2 marks)

7 (c) Sketch and label on the diagram below the arrangement that Young would have used to obtain his interference pattern.

(2 marks)

7 (d) State **two** differences in the appearance of the pattern obtained with a laser and that produced by a white light source such as a candle.

Difference 1 ....

....

Difference 2 ....

....

(2 marks)

7 (e) Explain how the wave theory of light accounts for the areas on the screen where the intensity is a minimum.

....

....

....

....

(2 marks)

END OF QUESTIONS

14

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