

Centre Number						Candidate Number				
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Candidate Signature										

For Examiner's Use	
Examiner's Initials	
Question	Mark
1	
2	
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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.

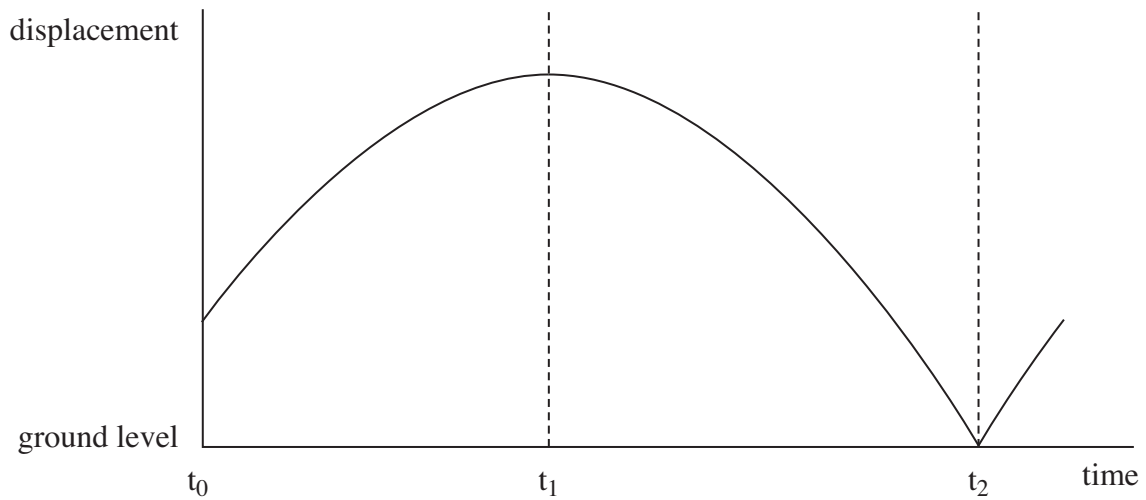


J U N 1 1 P H Y A 2 0 1

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**

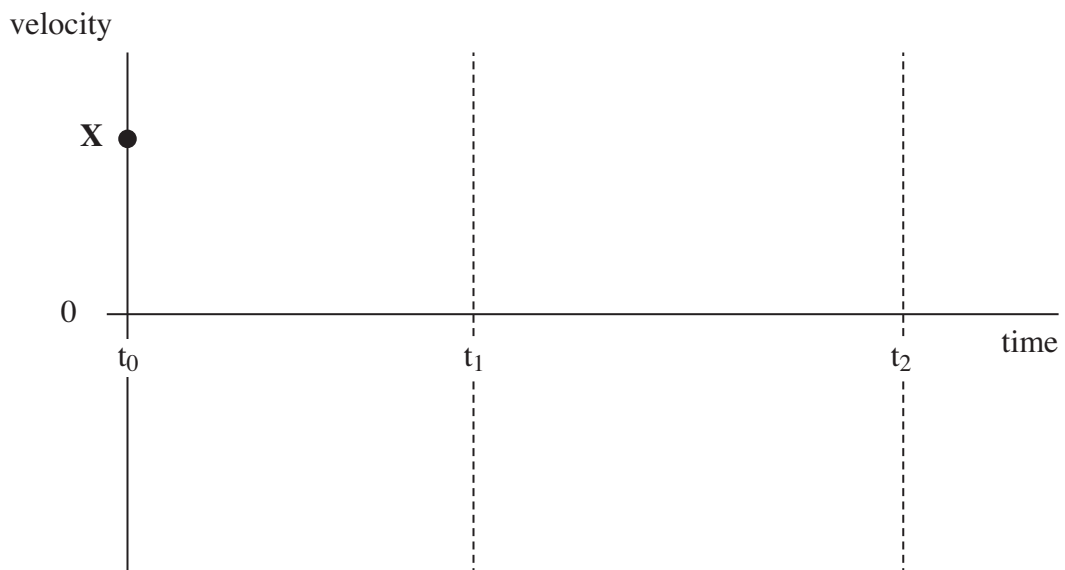


- 1 (a) (i)** State which feature of a displacement-time graph represents the velocity.

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(1 mark)

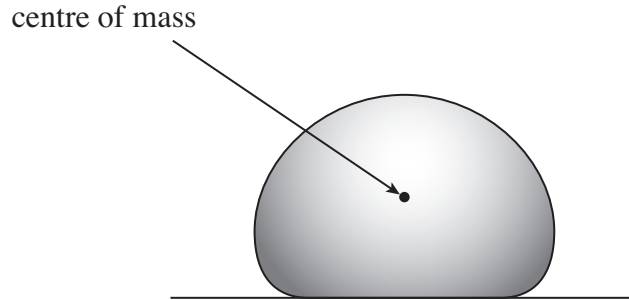
- 1 (a) (ii)** On the axes below, draw the shape of the velocity-time graph for the ball between  $t_0$  and  $t_2$ . The starting point is labelled **X**.

(3 marks)



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**.

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(2 marks)

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

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(2 marks)

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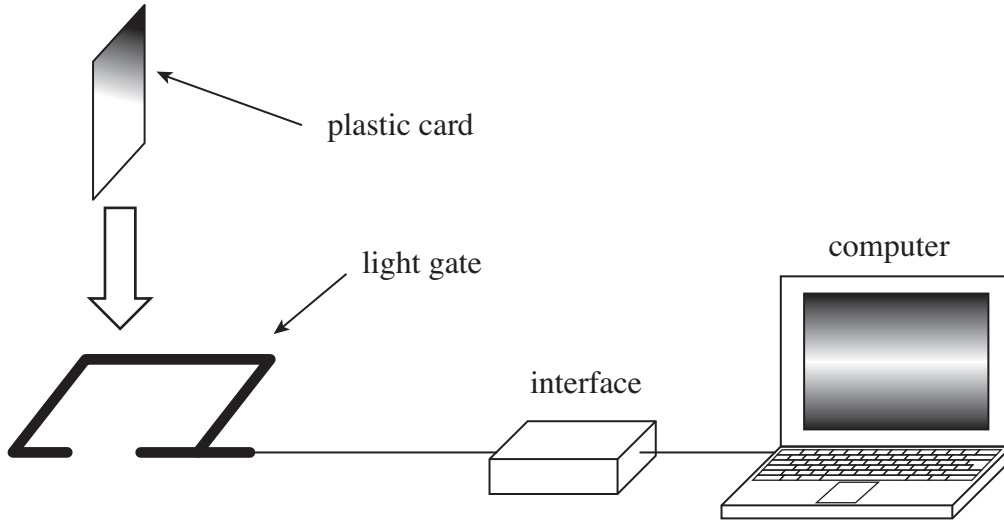
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- 2 A student measures the acceleration due to gravity,  $g$ , using the apparatus shown in **Figure 3**. A plastic card of known length is released from rest at a height of 0.50 m above a light gate. A computer calculates the velocity of the card 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  $3.10 \text{ ms}^{-1}$  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 = .....  $\text{ms}^{-2}$   
(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.

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(1 mark)



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

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*(2 marks)*

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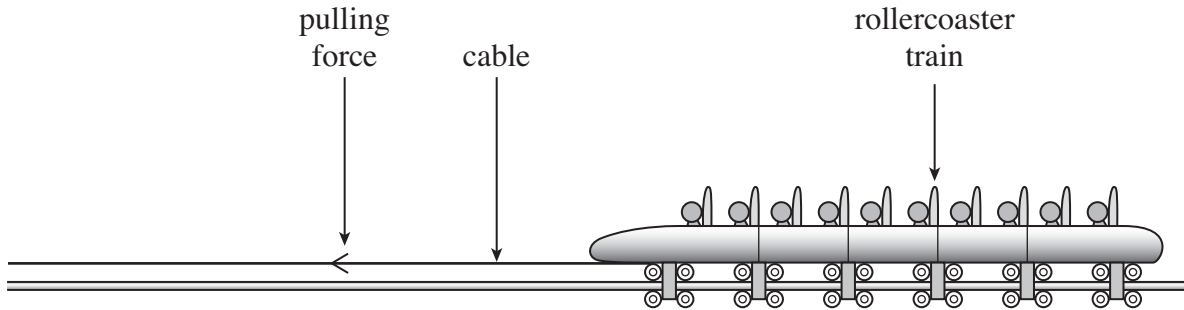
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- 3 **Figure 4** shows a rollercoaster train that is being accelerated when it is pulled horizontally by a cable.

**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 = .....  $\text{ms}^{-2}$   
(2 marks)

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

answer = .....  
(3 marks)



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

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.

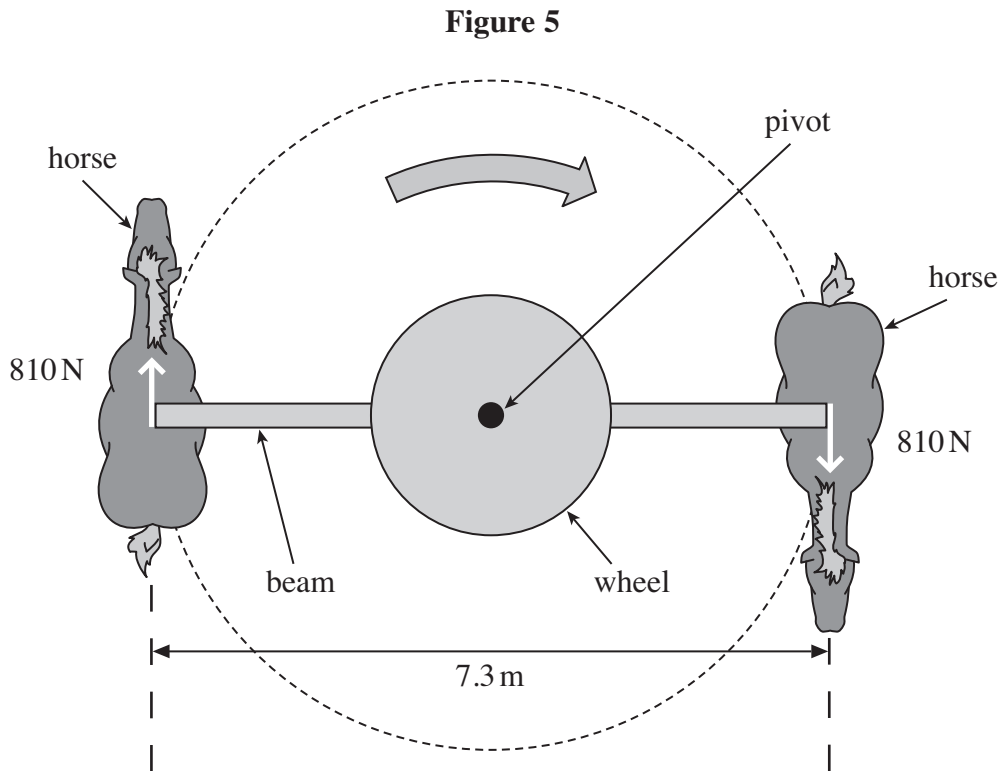
answer = ..... W  
(3 marks)

**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)



- 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.



- 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)





4 (b) The horses move at a constant speed of  $0.91 \text{ ms}^{-1}$ . 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 19<sup>th</sup> 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.

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(1 mark)

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5 (a) The speed of light is given by

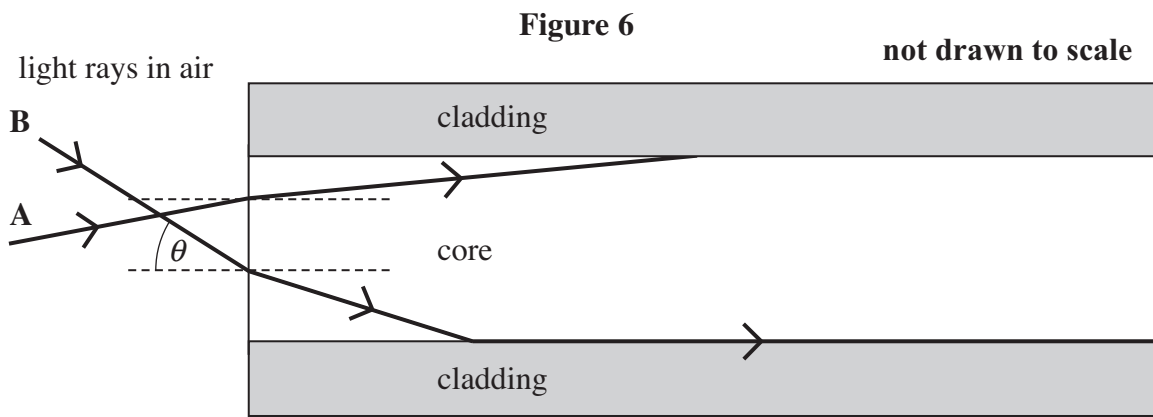
$$c = f \lambda$$

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

- $c$  .....
- $f$  .....
- $\lambda$  .....

(3 marks)

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



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  $2.04 \times 10^8 \text{ ms}^{-1}$ . 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  $80^\circ$ .

refractive index of the cladding = 1.45

(2 marks)

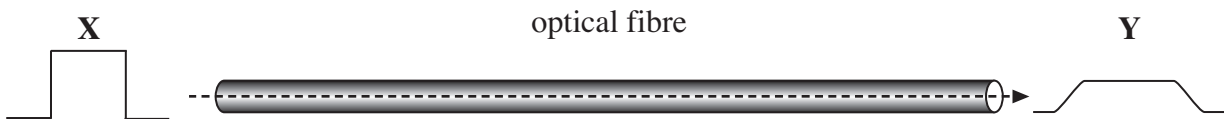


5 (d) Ray **B** enters the end of the fibre and refracts along the core-cladding boundary. Calculate the angle of incidence,  $\theta$ , of this ray at the point of entry to the fibre.

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**



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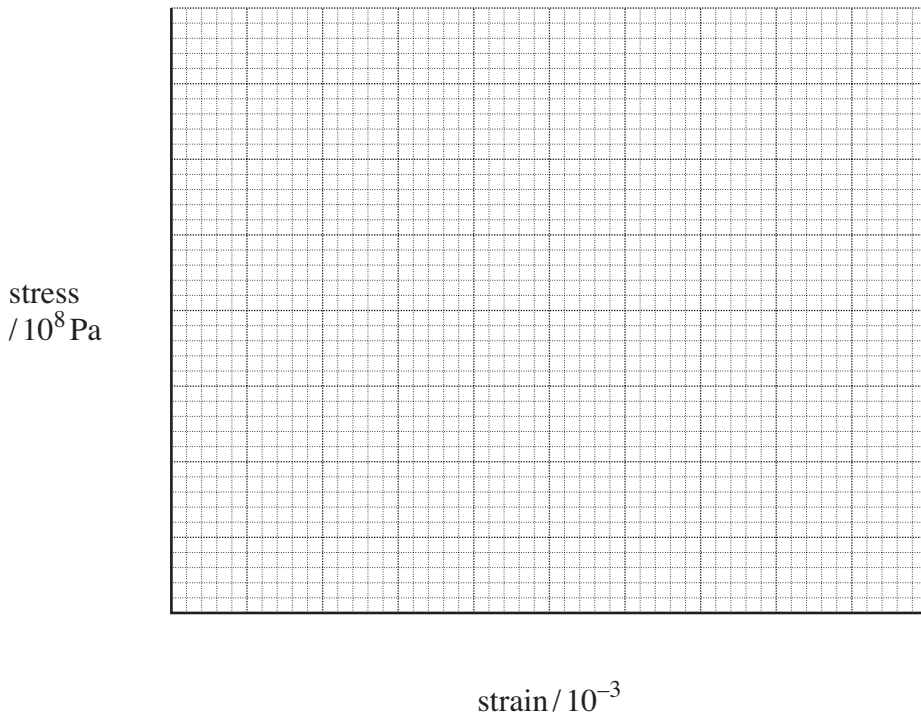
(2 marks)



**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



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

answer = ..... Pa  
(2 marks)



- 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 =  $1.90 \times 10^{11}$  Pa

answer = ..... m<sup>2</sup>  
(3 marks)

8

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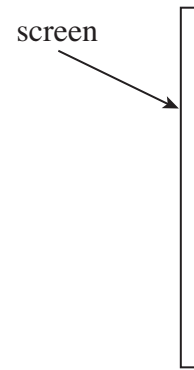
7 (b) In 1802 Thomas Young used candle light to observe the interference pattern from two narrow slits acting as *coherent light sources*.

Explain what is meant by coherent light sources.

.....  
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(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.

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(2 marks)

END OF QUESTIONS



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