

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 2010

# Physics A

# PHYA2

## Unit 2 Mechanics, Materials and Waves

Monday 18 January 2010 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. Answers written in margins or on blank pages will not be marked.
- 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.

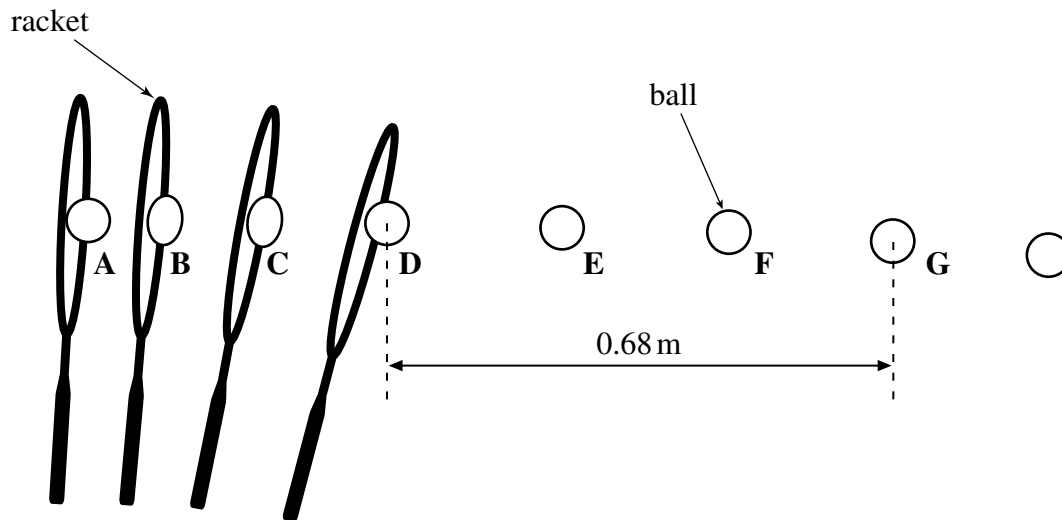


J A N 1 0 P H Y A 2 0 1

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

- 1 A digital camera was used to obtain a sequence of images of a tennis ball being struck by a tennis racket. The camera was set to take an image every 5.0 ms. The successive positions of the racket and ball are shown in **Figure 1**.

**Figure 1**



- 1 (a) The ball has a horizontal velocity of zero at **A** and reaches a constant horizontal velocity at **D** as it leaves the racket. The ball travels a horizontal distance of 0.68 m between **D** and **G**.
- 1 (a) (i) Show that the horizontal velocity of the ball between positions **D** and **G** in **Figure 1** is about  $45 \text{ m s}^{-1}$ .

(3 marks)



1 (a) (ii) Calculate the horizontal acceleration of the ball between **A** and **D**.

answer = .....  $\text{m s}^{-2}$   
(1 mark)

1 (b) At **D**, the ball was projected horizontally from a height of 2.3 m above level ground.

1 (b) (i) Show that the ball would fall to the ground in about 0.7 s.

(3 marks)

1 (b) (ii) Calculate the horizontal distance that the ball will travel after it leaves the racket before hitting the ground. Assume that only gravity acts on the ball as it falls.

answer = ..... m  
(2 marks)

1 (b) (iii) Explain why, in practice, the ball will not travel this far before hitting the ground.

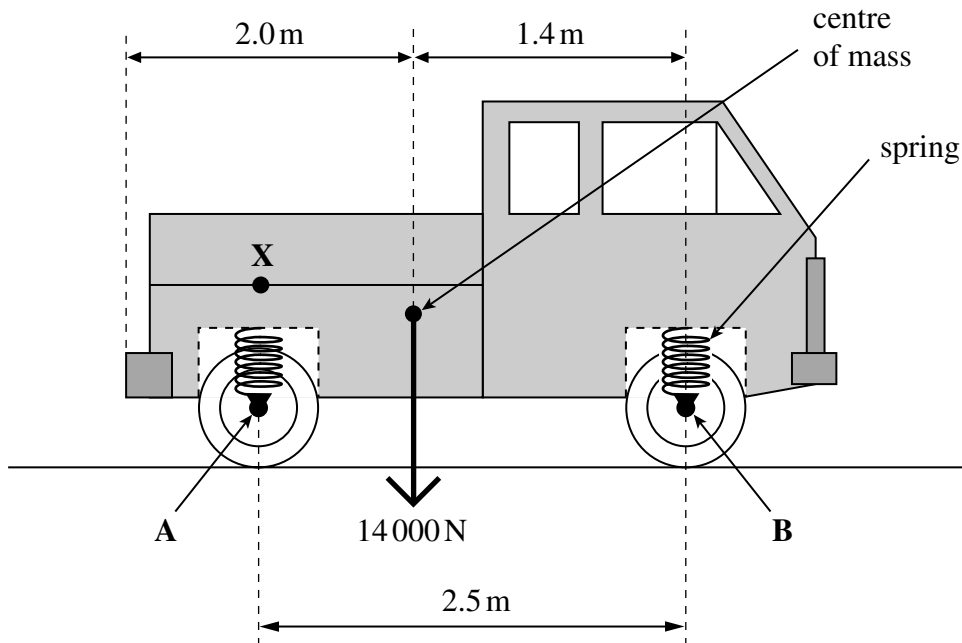
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(2 marks)



- 2 Heavy duty coil springs are used in vehicle suspensions. The pick-up truck shown in **Figure 2** has a weight of 14 000 N and length of 4.5 m. When carrying no load, the centre of mass is 2.0 m from the rear end. The part of the vehicle shown shaded in grey is supported by four identical springs, one near each wheel.

**Figure 2**



- 2 (a) (i) Define the moment of a force about a point.

.....

.....

.....

.....

(2 marks)

- 2 (a) (ii) State and explain which pair of springs, front or rear, will be compressed the most.

.....

.....

.....

.....

(2 marks)



- 2 (a) (iii) By taking moments about axle **B**, calculate the force exerted on the truck by each rear spring.

answer = ..... N  
(4 marks)

- 2 (b) The spring constant for each of these springs is  $100\,000\text{ N m}^{-1}$ .

Calculate the distance that each of these rear springs is compressed by this vehicle as shown in **Figure 2**.

answer = ..... m  
(2 marks)

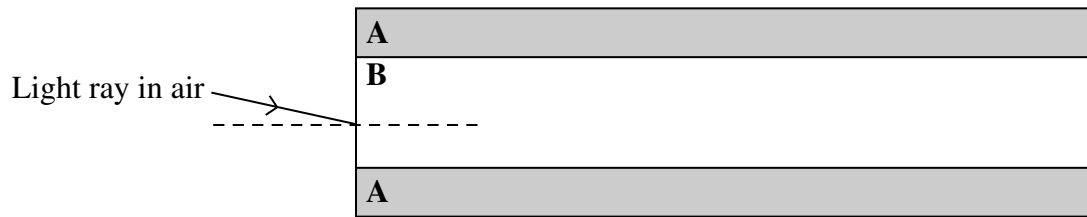
- 2 (c) The springs must not be compressed by more than an additional 0.065 m. Calculate the maximum load that could be placed at point **X**, which is directly above the centre of the rear axle **A**, as shown in **Figure 2**.

answer = ..... N  
(2 marks)



3 **Figure 3** shows a cross-section through a step index optical fibre.

**Figure 3**



3 (a) (i) Name the parts **A** and **B** of the fibre.

(1 mark)

<b>A</b>	
<b>B</b>	

3 (a) (ii) On **Figure 3**, draw the path of the ray of light through the fibre. Assume the light ray undergoes *total internal reflection* at the boundary between **A** and **B**.

(2 marks)

3 (b) Calculate the critical angle for the boundary between **A** and **B**. Give your answer to an appropriate number of significant figures.

The refractive index of part **A** = 1.46

The refractive index of part **B** = 1.48

answer = ..... degrees  
(2 marks)



3 (c) State and explain **one** reason why part **B** of the optical fibre is made as narrow as possible.

.....  
.....  
.....  
.....

(2 marks)

3 (d) State **one** application of optical fibres and explain how this has benefited society.

Application

.....  
.....

Benefit

.....  
.....

(2 marks)

9

**Turn over for the next question**

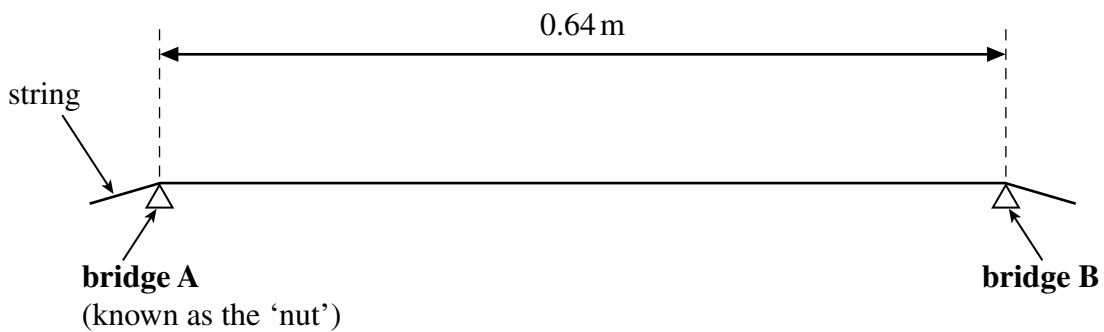
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4 **Figure 4** shows a side view of a string on a guitar. The string cannot move at either of the two bridges when it is vibrating. When vibrating in its fundamental mode the frequency of the sound produced is 108 Hz.

4 (a) (i) On **Figure 4**, sketch the stationary wave produced when the string is vibrating in its fundamental mode.

**Figure 4**



(1 mark)

4 (a) (ii) Calculate the wavelength of the fundamental mode of vibration.

answer = ..... m  
(2 marks)

4 (a) (iii) Calculate the speed of a progressive wave on this string.

answer = .....  $\text{m s}^{-1}$   
(2 marks)



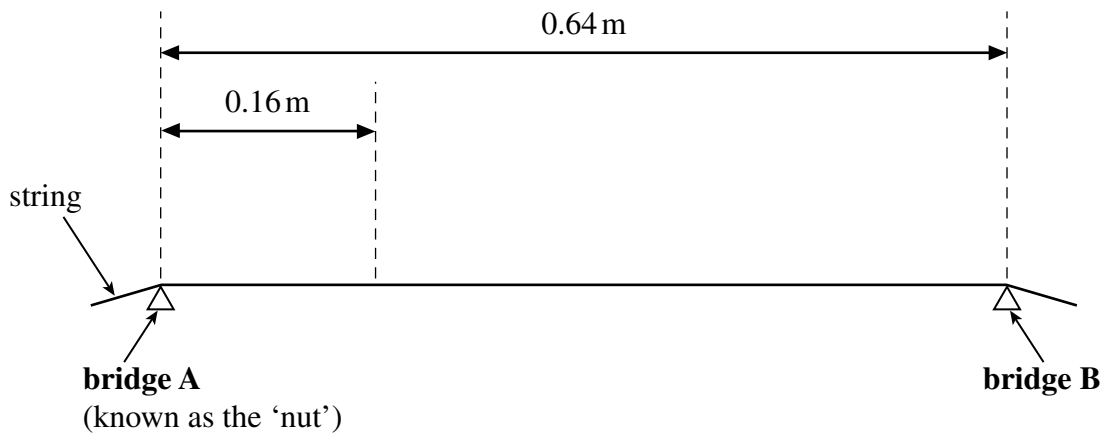


4 (b) While tuning the guitar, the guitarist produces an overtone that has a node 0.16 m from **bridge A**.

4 (b) (i) On **Figure 5**, sketch the stationary wave produced and label all nodes that are present.

(2 marks)

**Figure 5**



4 (b) (ii) Calculate the frequency of the overtone.

answer = ..... Hz  
(1 mark)

4 (c) The guitarist needs to raise the fundamental frequency of vibration of this string. State **one** way in which this can be achieved.

.....  
.....  
(1 mark)

Turn over ►



5 Just over two hundred years ago Thomas Young demonstrated the interference of light by illuminating two closely spaced narrow slits with light from a single light source.

5 (a) What did this suggest to Young about the nature of light?

.....  
.....

(1 mark)

5 (b) The demonstration can be carried out more conveniently with a laser. A laser produces *coherent, monochromatic* light.

5 (b) (i) State what is meant by monochromatic.

.....  
.....

5 (b) (ii) State what is meant by coherent.

.....  
.....

(2 marks)

5 (b) (iii) State **one** safety precaution that should be taken while using a laser.

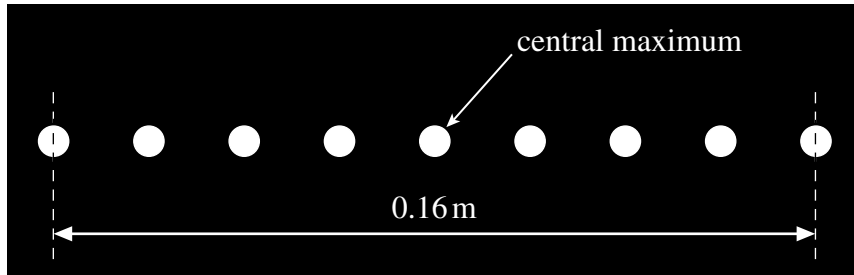
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(1 mark)



- 5 (c) **Figure 6** shows the maxima of a two slit interference pattern produced on a screen when a laser was used as a monochromatic light source.

**Figure 6**



The slit spacing = 0.30 mm.

The distance from the slits to the screen = 10.0 m.

Use **Figure 6** to calculate the wavelength of the light that produced the pattern.

answer = ..... m  
(3 marks)

- 5 (d) The laser is replaced by another laser emitting visible light with a shorter wavelength. State and explain how this will affect the spacing of the maxima on the screen.

.....  
 .....  
 .....  
 .....

(2 marks)

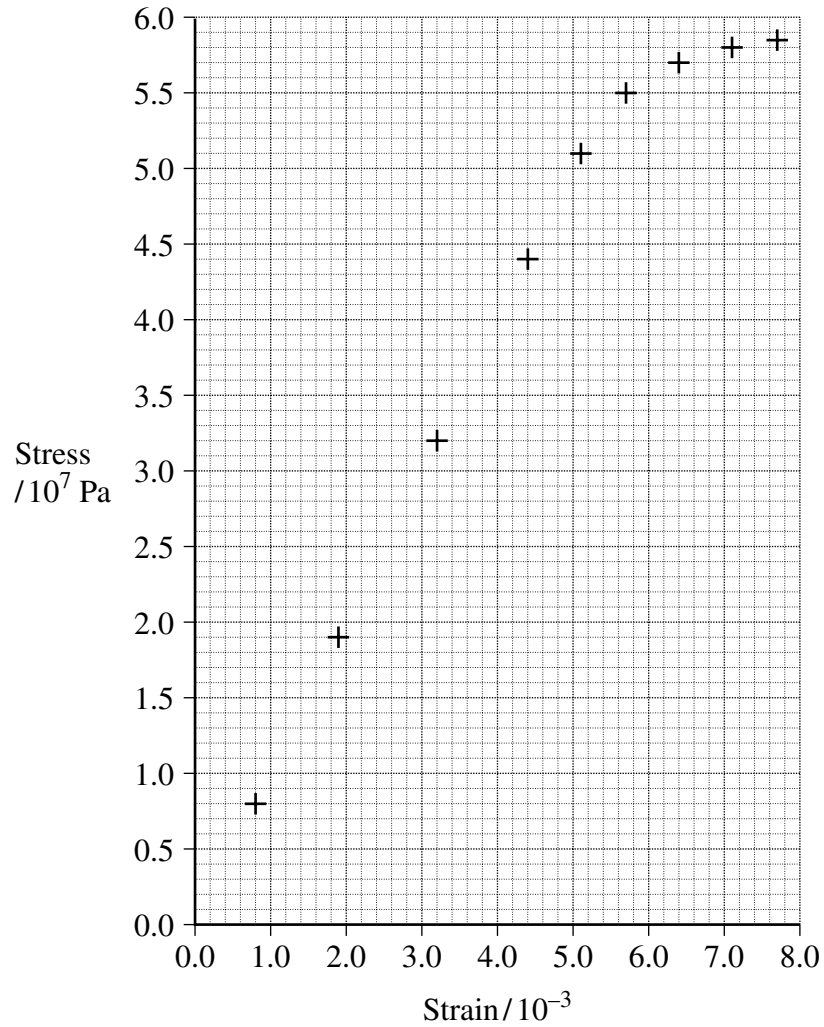
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- 6 (b) **Figure 7** is a plot of some results from an experiment in which a metal wire was stretched.

**Figure 7**



- 6 (b) (i) Draw a best-fit line using the data points.

(1 mark)

**Question 6 continues on the next page**

**Turn over** ►



6 (b) (ii) Use your line to find the Young modulus of the metal, stating an appropriate unit.

answer = .....  
(4 marks)

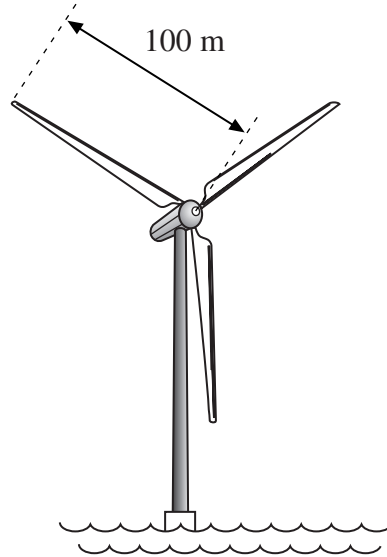
6 (c) After reaching a strain of  $7.7 \times 10^{-3}$ , the wire is to be unloaded. On **Figure 7**, sketch the line you would expect to obtain for this.  
(1 mark)

12
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- 7 It has been predicted that in the future large offshore wind turbines may have a power output ten times that of the largest ones currently in use. These turbines could have a blade length of 100 m or more. A turbine such as this is shown in **Figure 8**.

**Figure 8**



- 7 (a) At a wind speed of  $11 \text{ m s}^{-1}$  the volume of air passing through the blades each second is  $3.5 \times 10^5 \text{ m}^3$ .
- 7 (a) (i) Show that the mass of air that would pass through the blades each second is about  $4 \times 10^5 \text{ kg}$ .

The density of air is  $1.2 \text{ kg m}^{-3}$

(2 marks)

**Question 7 continues on the next page**

**Turn over** ►



7 (a) (ii) Calculate the kinetic energy of the air that would enter the turbine each second.

answer = ..... J  
(2 marks)

7 (a) (iii) It has been predicted that the turbine would produce an electrical power output of 10 MW in these wind conditions. Calculate the percentage efficiency of the turbine in converting this kinetic energy into electrical energy.

answer = ..... %  
(2 marks)

7 (b) State **one** advantage and **one** disadvantage of wind power in comparison to fossil fuel.

Advantage .....

Disadvantage .....

(2 marks)

8
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**END OF QUESTIONS**

