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 2009

Physics A PHYA2

Unit 2 Mechanics, Materials and Waves

Thursday 15 January 2009 1.30 pm to 2.45 pm

For this paper you must have:
- a calculator
- a ruler
- 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 Book* 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 car is travelling on a level road at a speed of 15.0 m s^{-1} towards a set of traffic lights when the lights turn red. The driver applies the brakes 0.5 s after seeing the lights turn red and stops the car at the traffic lights. The table below shows how the speed of the car changes from when the traffic lights turn red.

time/s	0.0	0.5	1.0	1.5	2.0	2.5	3.0	3.5
speed/m s^{-1}	15.0	15.0	12.5	10.0	7.5	5.0	2.5	0.0

1 (a) Draw a graph of speed on the y-axis against time on the x-axis on the grid provided.

(5 marks)

1 (b) (i) State and explain what feature of the graph shows that the car's deceleration was uniform.

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(2 marks)

1 (b) (ii) Use your graph to calculate the distance the car travelled after the lights turned red to when it stopped.

Answer .... m

(4 marks)

11

Turn over for the next question

2 (a) (i) State the difference between a scalar quantity and a vector quantity.

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(1 mark)

2 (a) (ii) State **two** examples of a scalar quantity and **two** examples of a vector quantity.

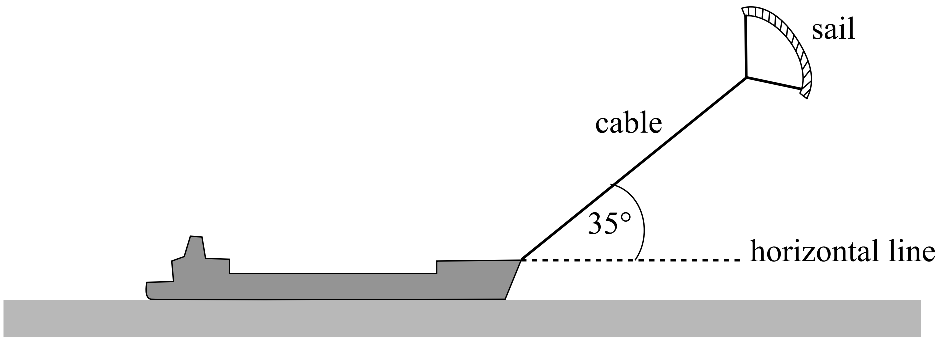
scalar quantities ....

vector quantities ....

(3 marks)

2 (b) **Figure 1** shows a ship fitted with a sail attached to a cable. The force of the wind on the sail assists the driving force of the ship's propellors.

Figure 1



The cable exerts a steady force of 2.8 kN on the ship at an angle of 35° above a horizontal line.

2 (b) (i) Calculate the horizontal and vertical components of this force.

horizontal component of force .... kN

vertical component of force .... kN

(2 marks)

2 (b) (ii) The ship is moving at a constant velocity of 8.3 m s^{-1} and the horizontal component of the force of the cable on the ship acts in the direction in which the ship is moving.
Calculate the power provided by the wind to this ship, stating an appropriate unit.

Answer ....
(3 marks)

2 (c) The cable has a diameter of 0.014 m. Calculate the tensile stress in the cable when it exerts a force of 2.8 kN on the ship, stating an appropriate unit.
Assume the weight of the cable is negligible.

Answer ....
(5 marks)

14

Turn over for the next question

Areas outside the box will not be scanned for marking

3 (a) State Hooke's law.

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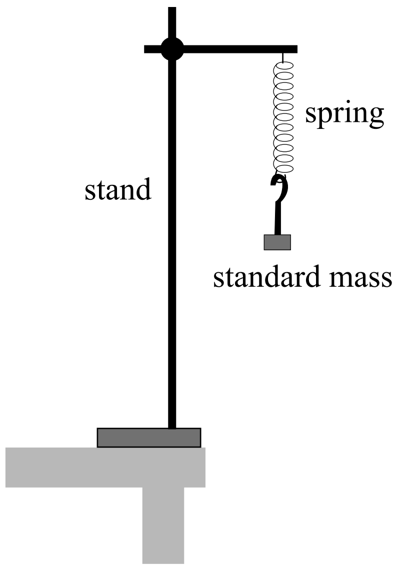
(2 marks)

3 (b) A student is asked to measure the mass of a rock sample using a steel spring, standard masses and a metre rule. She measured the unstretched length of the spring and then set up the arrangement shown in **Figure 2**.

Figure 2



3 (b) (i) Describe how you would use this arrangement to measure the mass of the rock sample. State the measurements you would make and explain how you would use the measurements to find the mass of the rock sample.
The quality of your written communication will be assessed in this question.

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(6 marks)

3 (b) (ii) State and explain **one** modification you could make to the arrangement in **Figure 2** to make it more stable.

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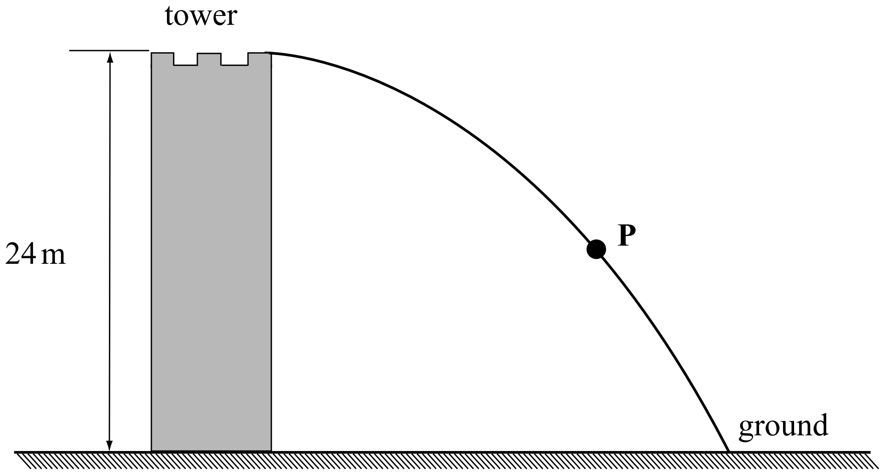
(2 marks)

10

Turn over for the next question

4 **Figure 3** shows the path of a ball thrown horizontally from the top of a tower of height 24 m which is surrounded by level ground.

Figure 3



4 (a) Using two labelled arrows, show on **Figure 3** the direction of the velocity, *v*, and the acceleration, *a*, of the ball when it is at point **P**.

(2 marks)

4 (b) (i) Calculate the time taken from when the ball is thrown to when it first hits the ground. Assume air resistance is negligible.

Answer .... s

(2 marks)

4 (b) (ii) The ball hits the ground 27 m from the base of the tower. Calculate the speed at which the ball is thrown.

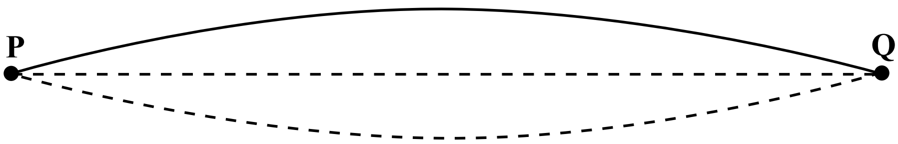
Answer .... $m\,s^{-1}$

(2 marks)

6

5 **Figure 4** represents a stationary wave formed on a steel string fixed at **P** and **Q** when it is plucked at its centre.

Figure 4



5 (a) Explain why a stationary wave is formed on the string.

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(3 marks)

5 (b) (i) The stationary wave in **Figure 4** has a frequency of 150 Hz. The string **PQ** has a length of 1.2 m.
Calculate the wave speed of the waves forming the stationary wave.

Answer .... $m\,s^{-1}$
(2 marks)

5 (b) (ii) On **Figure 5**, draw the stationary wave that would be formed on the string at the same tension if it was made to vibrate at a frequency of 450 Hz.

Figure 5

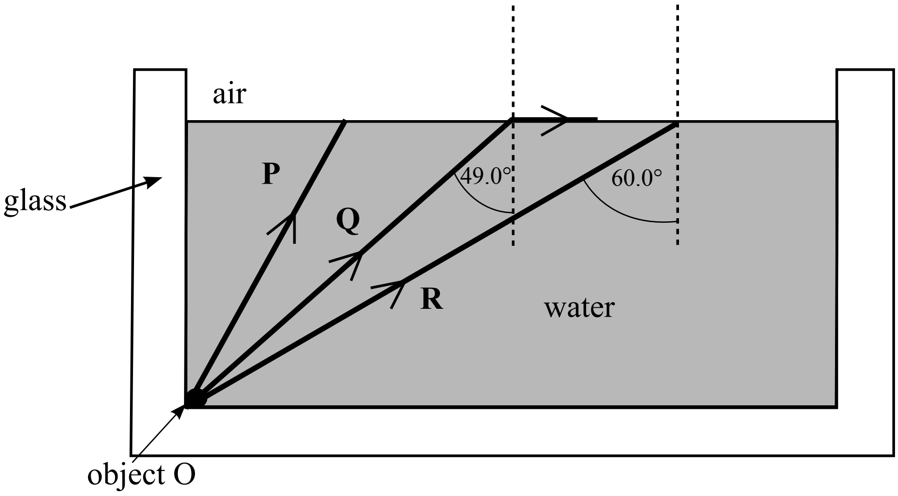
(2 marks)

7

Turn over ▸

6 **Figure 6** shows a rectangular glass fish tank containing water. Three light rays, **P**, **Q** and **R** from the same point on a small object O at the bottom of the tank are shown.

Figure 6



6 (a) (i) Light ray **Q** is refracted along the water-air surface. The angle of incidence of light ray **Q** at the water surface is 49.0°. Calculate the refractive index of the water. Give your answer to an appropriate number of significant figures.

Answer..............................

(1 mark)

6 (a) (ii) Draw on **Figure 6** the path of light ray **P** from the water-air surface.

(3 marks)

Areas outside the box will not be scanned for marking

6 (b) In **Figure 6**, the angle of incidence of light ray **R** at the water-air surface is 60.0°.

6 (b) (i) Explain why this light ray is totally internally reflected at the water surface.

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(2 marks)

6 (b) (ii) Draw the path of light ray **R** from the water surface and explain whether or not **R** enters the glass at the right-hand side of the tank.

the refractive index of the glass = 1.50

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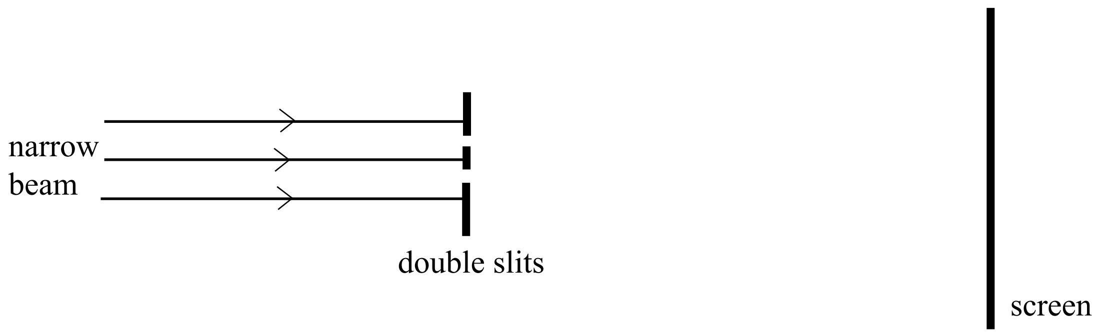
(4 marks)

10

Turn over for the next question

7 A narrow beam of monochromatic red light is directed at a double slit arrangement. Parallel red and dark fringes are seen on the screen shown in **Figure 7**.

Figure 7



7 (a) (i) Light passing through each slit spreads out. What is the name for this effect?

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(1 mark)

7 (a) (ii) Explain the formation of the fringes seen on the screen.

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(4 marks)

7 (a) (iii) The slit spacing was 0.56 mm. The distance across 4 fringe spacings was 3.6 mm when the screen was at a distance of 0.80 m from the slits. Calculate the wavelength of the red light.

Answer .... m

(4 marks)

7 (b) Describe how the appearance of the fringes would differ if white light had been used instead of red light.

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(3 marks)

12

END OF QUESTIONS

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Physics A PHYA2

Unit 2 Mechanics, Materials and Waves

Data and Formulae Booklet

DATA
FUNDAMENTAL CONSTANTS AND VALUES

Quantity	*Symbol*	*Value*	*Units*
speed of light in vacuo	c	3.00×10^{8}	$m\,s^{-1}$
permeability of free space	μ_0	$4\pi \times 10^{-7}$	$H\,m^{-1}$
permittivity of free space	ε_0	8.85×10^{-12}	$F\,m^{-1}$
charge of electron	e	-1.60×10^{-19}	C
the Planck constant	h	6.63×10^{-34}	J s
gravitational constant	G	6.67×10^{-11}	$N\,m^{2}\,kg^{-2}$
the Avogadro constant	N_A	6.02×10^{23}	mol^{-1}
molar gas constant	R	8.31	$J\,K^{-1}\,mol^{-1}$
the Boltzmann constant	k	1.38×10^{-23}	$J\,K^{-1}$
the Stefan constant	σ	5.67×10^{-8}	$W\,m^{-2}\,K^{-4}$
the Wien constant	α	2.90×10^{-3}	m K
electron rest mass (equivalent to 5.5×10^{-4} u)	m_e	9.11×10^{-31}	kg
electron charge/mass ratio	e/m_e	1.76×10^{11}	$C\,kg^{-1}$
proton rest mass (equivalent to 1.00728 u)	m_p	$1.67(3) \times 10^{-27}$	kg
proton charge/mass ratio	e/m_p	9.58×10^{7}	$C\,kg^{-1}$
neutron rest mass (equivalent to 1.00867 u)	m_n	$1.67(5) \times 10^{-27}$	kg
gravitational field strength	g	9.81	$N\,kg^{-1}$
acceleration due to gravity	g	9.81	$m\,s^{-2}$
atomic mass unit (1u is equivalent to 931.3 MeV)	u	1.661×10^{-27}	kg

GEOMETRICAL EQUATIONS

arc length	$= r\theta$
circumference of circle	$= 2\pi r$
area of circle	$= \pi r^2$
surface area of cylinder	$= 2\pi rh$
volume of cylinder	$= \pi r^2 h$
area of sphere	$= 4\pi r^2$
volume of sphere	$= \frac{4}{3}\pi r^3$

ASTRONOMICAL DATA

Body	*Mass/kg*	*Mean radius/m*
Sun	1.99×10^{30}	6.96×10^{8}
Earth	5.98×10^{24}	6.37×10^{6}

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AS FORMULAE

PARTICLE PHYSICS

Rest energy values

class	*name*	*symbol*	*rest energy /MeV*
photon	photon	γ	0
lepton	neutrino	ν_e	0
		ν_μ	0
	electron	$e^\pm$	0.510999
	muon	$\mu^\pm$	105.659
mesons	π meson	$\pi^\pm$	139.576
		π^0	134.972
	K meson	$K^\pm$	493.821
		K^0	497.762
baryons	proton	p	938.257
	neutron	n	939.551

Properties of quarks

antiquarks have opposite signs

type	*charge*	*baryon number*	*strangeness*
u	$+\frac{2}{3}e$	$+\frac{1}{3}$	0
d	$-\frac{1}{3}e$	$+\frac{1}{3}$	0
s	$-\frac{1}{3}e$	$+\frac{1}{3}$	-1

Properties of Leptons

	Lepton number
particles: e^-, ν_e ; μ^-, ν_μ	+1
antiparticles: e^+, $\overline{\nu_e}$; μ^+, $\overline{\nu_\mu}$	–1

Photons and Energy Levels

photon energy $E = hf = hc/\lambda$

photoelectricity $hf = \phi + E_{K\,(max)}$

energy levels $hf = E_1 - E_2$

de Broglie Wavelength $\lambda = \frac{h}{p} = \frac{h}{mv}$

ELECTRICITY

current and pd $I = \frac{\Delta Q}{\Delta t}$ $V = \frac{W}{Q}$ $R = \frac{V}{I}$

emf $\varepsilon = \frac{E}{Q}$ $\varepsilon = I(R + r)$

resistors in series $R = R_1 + R_2 + R_3 + \ldots$

resistors in parallel $\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \ldots$

resistivity $\rho = \frac{RA}{L}$

power $P = VI = I^2R = \frac{V^2}{R}$

alternating current $I_{rms} = \frac{I_0}{\sqrt{2}}$ $V_{rms} = \frac{V_0}{\sqrt{2}}$

MECHANICS

moments moment $= Fd$

velocity and acceleration $v = \frac{\Delta s}{\Delta t}$ $a = \frac{\Delta v}{\Delta t}$

equations of motion $v = u + at$ $s = \frac{(u+v)}{2}t$

$v^2 = u^2 + 2as$ $s = ut + \frac{1}{2}at^2$

force $F = ma$

work, energy and power $W = F\,s\cos\theta$

$E_K = ½\,m\,v^2$ $\Delta E_P = mg\Delta h$

$P = \frac{\Delta W}{\Delta t}$, $P = Fv$

efficiency $= \frac{\text{useful output power}}{\text{input power}}$

MATERIALS

density $\rho = \frac{m}{V}$ Hooke's law $F = k\,\Delta L$

Young modulus $= \frac{\text{tensile stress}}{\text{tensile strain}}$ tensile stress $= \frac{F}{A}$

tensile strain $= \frac{\Delta L}{L}$

energy stored $E = \frac{1}{2}F\Delta L$

WAVES

wave speed $c = f\lambda$ *period* $T = \frac{1}{f}$

fringe spacing $w = \frac{\lambda D}{s}$ *diffraction grating* $d\sin\theta = n\lambda$

refractive index of a substance s, $n = \frac{c}{c_s}$

for two different substances of refractive indices n_1 *and* n_2,

law of refraction $n_1\sin\theta_1 = n_2\sin\theta_2$

critical angle $\sin\theta_c = \frac{n_2}{n_1}$ for $n_1 > n_2$