Name:..... Centre Number:.....

Candidate Number:..... Set (Please circle): 4P1 AF 4P2 WEB
4P3 JAAB 4P4 JWC
4P5 MJR

Winchester College Physics Mock
Paper 2
Monday 24th April 2017

Time allowed: 100 min

Write on the exam paper in dark blue or black pen. You may use a soft pencil for any diagrams, graphs or rough working.

You may use a calculator.

The number of marks for the written answer questions is at the end of each question or part question.

You may lose marks if you do not show your working or if you do not use appropriate units.

1) (a) Define *specific latent heat of fusion*.

.....

.....

.....[2]

(b) A mass of 24 g of ice at –15 °C is taken from a freezer and placed in a beaker containing 200 g of water at 28 °C. Data for ice and for water are given in Fig. 3.1.

	specific heat capacity / J kg^{-1} K^{-1}	specific latent heat of fusion / J kg^{-1}
ice	2.1×10^3	3.3×10^5
water	4.2×10^3	–

Fig. 3.1

(i) Calculate the quantity of thermal energy required to convert the ice at –15 °C to water at 0 °C.

energy = ... J [3]

(ii) Assuming that the beaker has negligible mass, calculate the final temperature of the water in the beaker.

temperature = ... °C [3]

Total Question 1 [8]

2)

(a) Explain what is meant by a *standing wave*.

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.....[2]

(b) Describe one method of setting up a standing wave. Use a diagram with your answer and state the source of waves you are suggesting.

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.....[4]

(c) The pattern in Fig. 5.1 shows how the displacement of a standing wave of amplitude A varies with the distance x along the wave at a time $t = 0$.

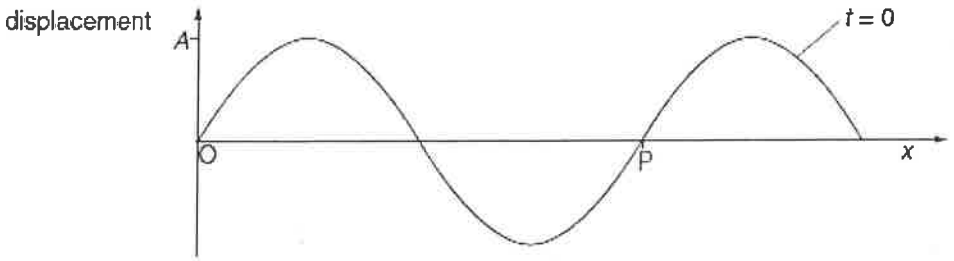

Fig. 5.1

(i) What does the distance OP represent?

.....[1]

(ii) On Fig. 5.1, sketch and label graphs to show the pattern at times

$$t = \frac{T}{2} \text{ and } t = \frac{T}{4} \text{ and } t = \frac{7T}{8}$$

where T is the time period of the oscillation. [3]

Total Question 2 [10]

3) A clean magnesium plate is placed in an evacuated glass container and illuminated with ultra-violet radiation of wavelength 250 nm, as shown in Fig. 7.1. Another metal plate is at the opposite end of the container and the two plates are connected through a microammeter to a variable d.c. supply. The polarity of the variable d.c. supply can be reversed.

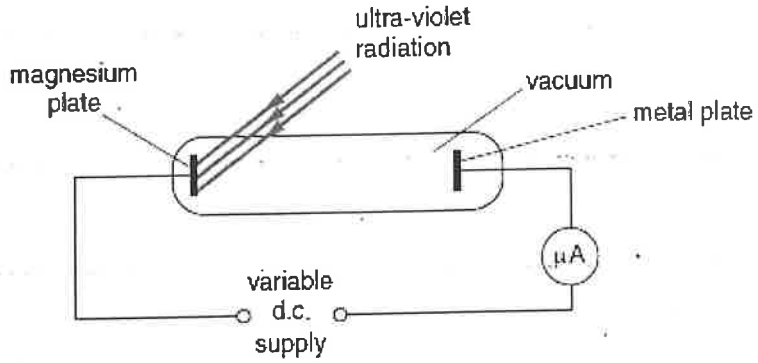

Fig. 7.1

(a) State the name of the effect that causes electrons to be emitted from the magnesium plate.

.....[1]

(b) Calculate the photon energy of the ultra-violet radiation

(i) in joules,

energy = ... J [2]

(ii) in electron-volts.

energy = ... eV [1]

(c) The work function of magnesium is 3.69 eV. Calculate the maximum energy, in eV, of electrons emitted from the magnesium plate.

energy = ... eV [1]

Question 3 continued on next page

3)

(d) Sketch a graph on the axes of Fig 7.2 to show how the current I in the microammeter will vary with the potential difference V between the two metal plates.

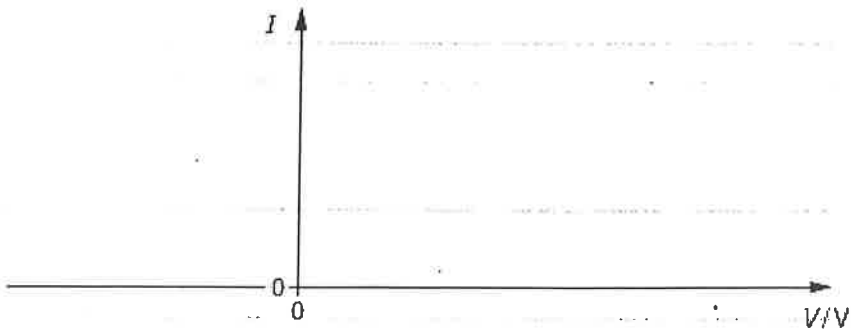

Fig. 7.2

[3]

(e) Add another line on your sketch graph to show the effect of reducing the intensity of the ultra-violet radiation. Label this line 'lower intensity'. [2]

(f) Explain why the answer to **(e)** was so unexpected when the experiment was first performed.

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.....[3]

Total Question 3 [13]

4) Diamonds sparkle because light entering the diamond undergoes numerous internal reflections before emerging.

Fig. 7.1 shows the path of a ray of light through a diamond.

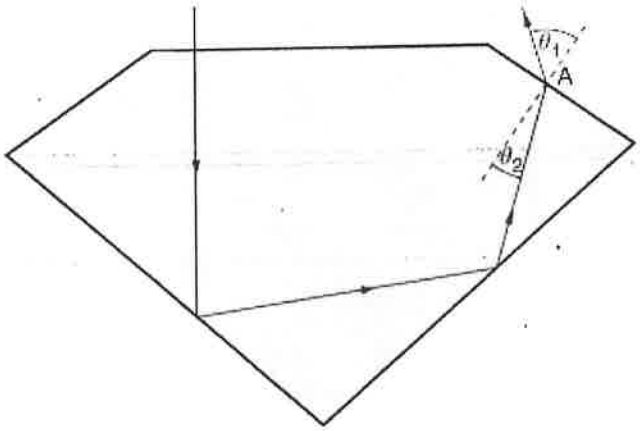

Fig. 7.1 (not to scale)

(a) The critical angle of light in diamond is 24°. Calculate the refractive index n of diamond to 2 decimal places.

n = ... [2]

(b) The ray finally emerges at the point labelled A. The angle of incidence θ_2 within the diamond is 19.0°.

(i) Calculate the angle of refraction θ_1 in air.

θ_1 = ... [1]

Question 4 continued on next page

4) -(ii) Place ticks in the table below to identify the effect on waves of light as they refract from diamond into air at A.

wave property of the light	effect		
	increase	unchanged	decrease
speed			
wavelength			
frequency			

[3]

Total Question 4 [6]

5) Six identical numbered cubes, each of mass m, lie in a straight line on a smooth horizontal table, Figure 1.a, touching adjacent cubes. A constant force F is applied along the line of cubes.

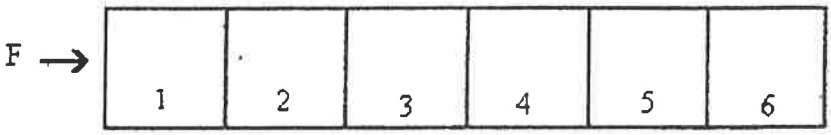

Figure 1.a

Derive expressions for:

(i) the acceleration of the system

(ii) the resultant force on each cube.

(iii) the force exerted on the fifth cube by the fourth cube.

Total Question 5 [4]

6) A bullet of mass 2.0 g is fired horizontally into a block of wood of mass 600 g. The block is suspended from strings so that it is free to move in a vertical plane.
The bullet buries itself in the block. The block and bullet rise together through a vertical distance of 8.6 cm, as shown in Fig. 3.1.

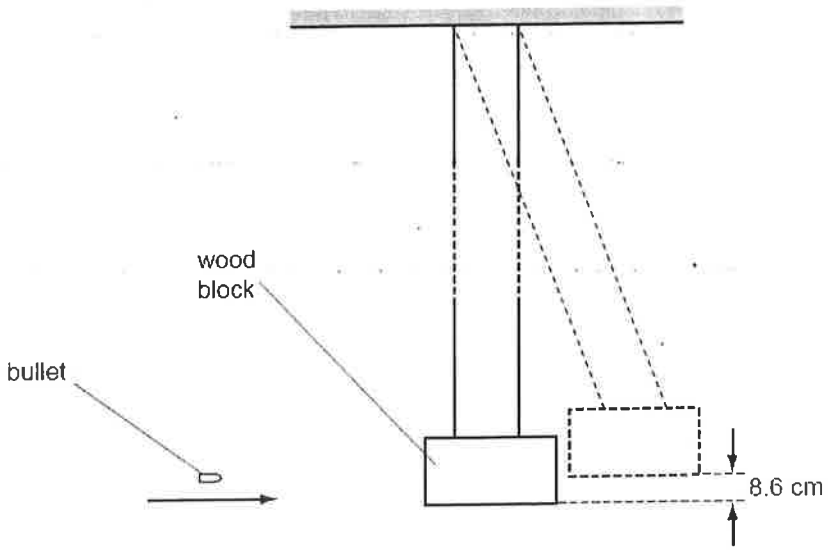

Fig. 3.1

(a) (i) Calculate the change in gravitational potential energy of the block and bullet.

change = ... J [2]

(ii) Show that the initial speed of the block and the bullet, after they began to move off together, was 1.3 m s^{-1}.

[1]

Question 6 continued on next page

6) **(b)** Using the information in **(a)(ii)** and the principle of conservation of momentum, determine the speed of the bullet before the impact with the block.

speed = ... $m\,s^{-1}$ [2]

(c) **(i)** Calculate the kinetic energy of the bullet just before impact.

kinetic energy = ... J [2]

(ii) State and explain what can be deduced from your answers to **(c)(i)** and **(a)(i)** about the type of collision between the bullet and the block.

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.....[2]

Total Question 6 [9]

7)

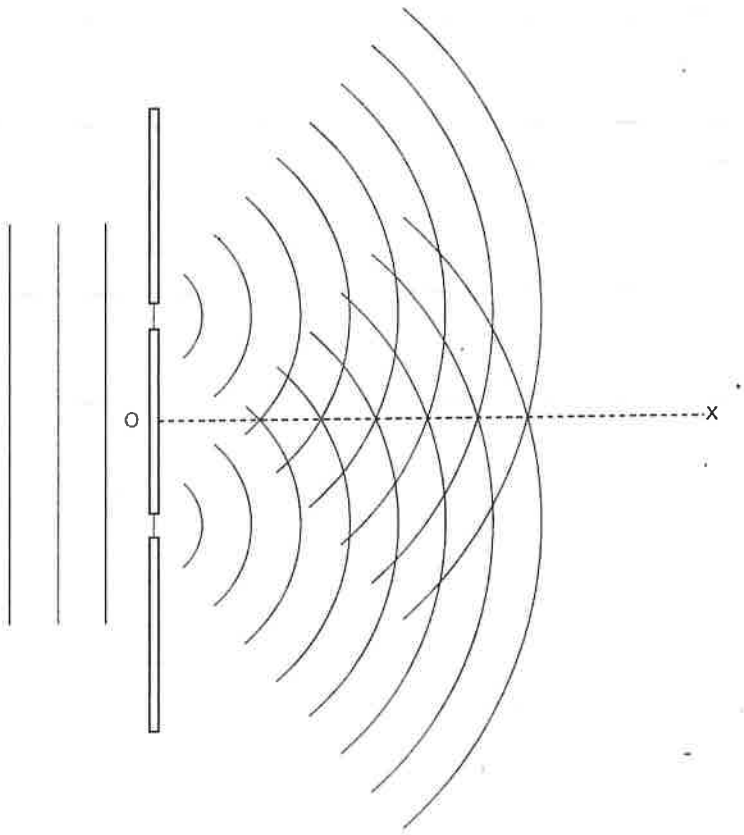

Fig. 6.1

Fig. 6.1 shows wavefronts incident on, and emerging from, a double slit arrangement.

The wavefronts represent successive crests of the wave. The line OX shows one direction along which constructive interference may be observed.

(a) State the principle of superposition.

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.....

..... [3]

(b) On Fig. 6.1, draw lines to show

(i) a second direction along which constructive interference may be observed (label this line CC),

(ii) a direction along which destructive interference may be observed (label this line DD)

[2]

Question 7 continued on next page

7) **(c)** Light of wavelength 650 nm is incident normally on a double slit arrangement. The interference fringes formed are viewed on a screen placed parallel to and 1.2 m from the plane of the double slit, as shown in Fig. 6.2.

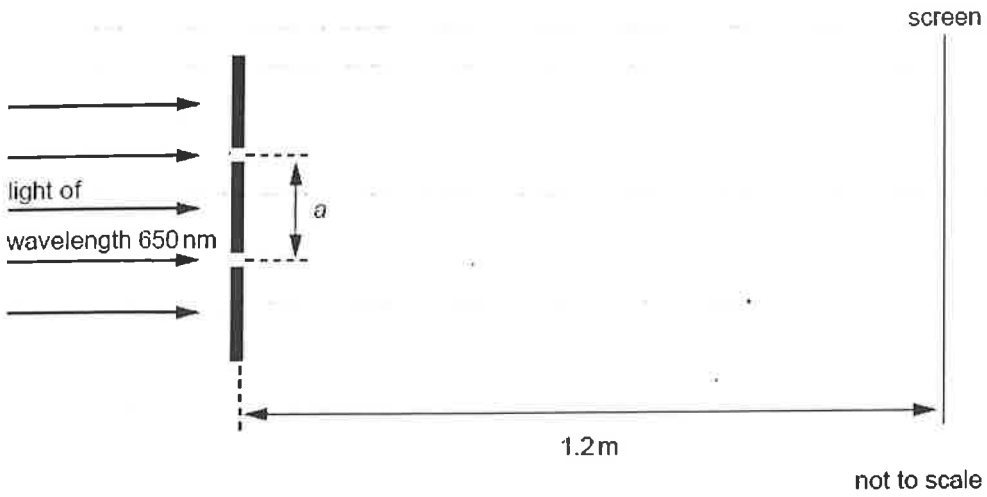

Fig. 6.2

The fringe separation is 0.70 mm.

(i) Calculate the separation *a* of the slits.

separation = ... m [3]

(ii) The width of both slits is increased without changing their separation *a*. State the effect, if any, that this change has on

1. the separation of the fringes.

.....

2. the brightness of the light fringes,

.....

3. the brightness of the dark fringes.

.....

[3]

Total question 7 [11]

8) In 2011, physicists claimed to have detected neutrinos travelling faster than the speed of light. The neutrinos travelled from CERN, in Switzerland, to the OPERA particle detector at the Gran Sasso laboratory in Italy.

The experiment that produced a result suggesting that neutrinos travel faster than the speed of light was repeated 15000 times. It caused a sensation because this seemed to violate Einstein's theory of relativity. However, many physicists assumed that there must be a measurement error in the experiment. CERN called for other researchers to make independent checks of the result and four different experiments all showed that the neutrinos did not travel faster than the speed of light.

(a) State the postulates of Einstein's special theory of relativity.

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.....[2]

(b) Explain why a value of neutrino velocity v, greater than the speed of light c, would cause problems for the theory of relativity. Your answer should refer to Einstein's 'gamma-factor',

$$\gamma = \frac{1}{\sqrt{\left(1 - \frac{v^2}{c^2}\right)}}.$$

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.....[2]

(c) A student suggests that time dilation effects can be measured directly by placing a 'light' clock inside a moving spacecraft alongside a wristwatch. He argues that the clock will lose more and more time with respect to the wristwatch. Discuss and explain whether or not this method would work.

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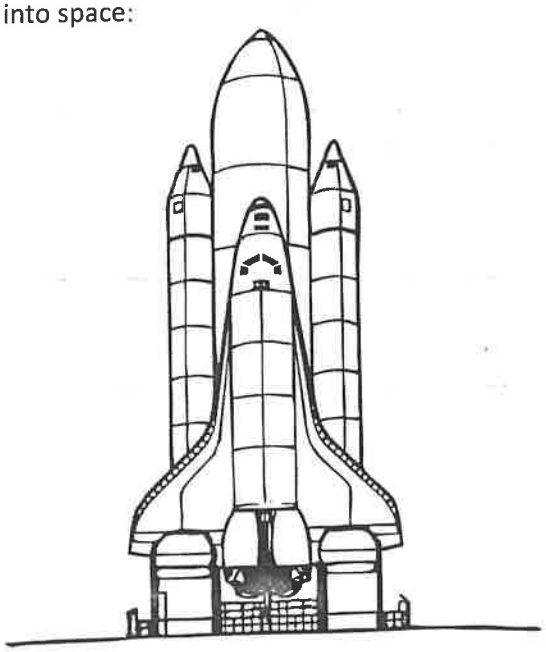
..... [2]

Total question 8 [6]

9) The (now defunct) NASA space shuttle did a great job of ferrying people and equipment into space:



Here are some data about the space shuttle at the instant of take-off:

- Total weight = 19.7 MN
- Total thrust upwards = 28MN
- Total rate of burning fuel = 9800 kg/s

a) Use Newton III to explain how the rocket develops thrust.

[2]

b) Use the data to calculate the (mean) exhaust velocity of the gases being ejected by the rockets.

[2]

c) Calculate the initial acceleration of the space shuttle.

[3]

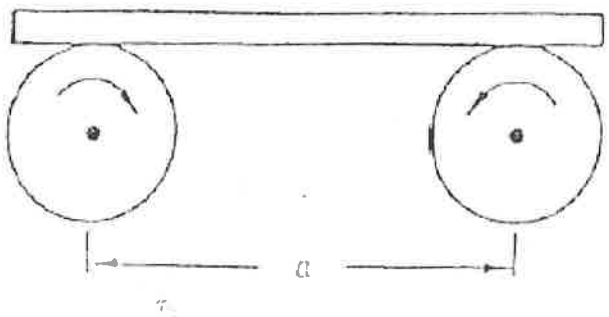
Question 9 continued on the next page

9) d) Show that after 110 seconds the acceleration has increased to over 20 m/s^2. Assume that the thrust stays the same, gravity stays the same, the rocket goes vertically upwards and there is no air resistance.

[4]

Total Question 9 [11]

10) A straight uniform horizontal rod of mass M rests symmetrically on top of two rollers as shown below. The rollers, separated by a distance a, are rotating at high speed in opposite directions. The sliding friction force acting at each point of contact on the rollers is given by μN, where N is the normal reaction force at that point and μ is the coefficient of sliding friction.



The rod is now displaced from this equilibrium position a small horizontal distance x to the left, and then released.

a) Explain qualitatively why the rod will experience a nett force back towards the equilibrium position.

[2]

Question 10 continued on next page

10) b) Show that the horizontal force acting on the rod is proportional to x and in the opposite direction to x.

[4]

c) Show that the constant of proportionality equals 49 N/m, given that:
M = 2kg, μ = 0.5 and a = 0.4 m.

[2]

Total question 10 [8]

Total marks for Short Answer questions [86]