2008 AS PHYSICS COMPETITION PAPER

ONE HOUR PHYSICS COMPETITION PAPER

FRIDAY 14 th MARCH 2008

We hope teachers will set and mark the enclosed paper for their AS students, or equivalent students in Scotland. The solutions and marking scheme are contained herein. It is intended that the paper should be taken on Friday 14 th March. However if this is not possible, any date during the period 10th –15th March will be acceptable. Scripts of the Gold Medallists and requests for certificates must be posted in sufficient time to arrive by first class post on Monday 31st March at the Olympiad Office at the University of Kent. Any scripts arriving after this date cannot be considered for an award.

After the scripts have been marked please send those scripts with marks of 38 and above to me , the scripts of the Gold Medal Certificate students, in order to be considered for the award of a book prize, together with the entry form ,which is on the following page, and request form for certificates to:

Dr Cyril Isenberg
AS Physics Competition
Department of Electronics
University of Kent
Canterbury
Kent CT2 7NT

We will invite the five outstanding Gold Medallists, together with their teachers, to the Physics Challenge Presentation Ceremony at The Royal Society in London on Thursday 24 April 2008. Prizes and certificates will be despatched to all remaining medallists, who are not amongst those invited to the Presentation, in May. Teachers are requested to complete the certificates according to the medal scheme specified on the last page, and present them to their students .

2008 AS PHYSICS COMPETITION

ENTRY FORM

Name of teacher ______________________________

School ______________________________

Address ______________________________

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Tel. No. ______________________________

Email ______________________________

TOTAL NUMBER OF ENTRIES __________

GOLD MEDALLISTS: Full names and marks of Gold Medallists with marks in the range 38 - 50 for consideration of the award of a book prize.

NAME	TOTAL MARK	NAME	TOTAL MARK

Please complete and return the request form for certificates on the last page.

TEACHERS' COMMENTS

We welcome comments concerning questions in this AS Physics Competition paper and suggestions for possible future challenging questions.
Comments:

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2008 AS PHYSICS CERTIFICATES

All Participating students will receive a certificate. They will be awarded Gold, Silver, Bronze and Participation Medal Certificates, based on their marks, according to the scheme below:

Medal Certificate	Gold	Silver	Bronze	Participation
Mark Range	50 – 38	37–31	30 - 20	19 – 0
No. of certs. Requested				

Total Number of Entries	

NAME OF TEACHER ______________________________

NAME OF SCHOOL ______________________________

ADDRESS OF SCHOOL ______________________________

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Please return to:

Dr Cyril Isenberg
AS Physics Competition
Department of Electronics
University of Kent
Canterbury
Kent CT2 7NT

AS COMPETITION PAPER 2008

Name	
School	
Town & County	

Total Mark/50

Time Allowed: ***One hour***

Attempt as many questions as you can.

Write your answers on this question paper.

Marks allocated for each question are shown in brackets on the right.

You may use any calculator.

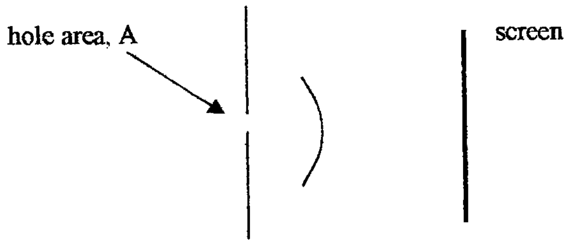
Allow no more than 10 minutes for section A.

The gravitational field strength on the earth is 9.8 N/kg

Section A: Multiple Choice

Circle the correct answer to each question. There is only one correct answer.

1. A beam of light of uniform intensity and of a single wavelength strikes a screen in which there is a small circular hole of area A. Some of the light passes through, and then spreads by diffraction, as shown below.



At the centre of the diffracted wave which reaches the centre of the screen, the intensity of the light is I_o (intensity is the power per unit area). When the hole is made narrower, then the angular width of the beam increases, in such a way that for the diffracted beam, half the diameter of the hole will result in twice the width of the beam. If the diameter of the hole is halved, then what will be the new intensity at the centre of the diffracted beam?

A $I_o/2$ B $I_o/4$ C $I_o/8$ D $I_o/16$

2. The earth orbits the sun once a year and the moon orbits the earth about once a month. From the earth you can observe the changing phases of the moon. If an observer stands on the moon and looks at the earth, what would be the period of the phases of the earth seen by that observer?

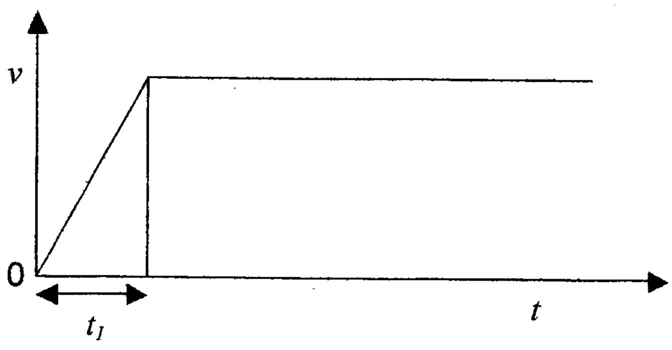
A Same period as the phases of the moon

B A little longer than the period for the phases of the moon

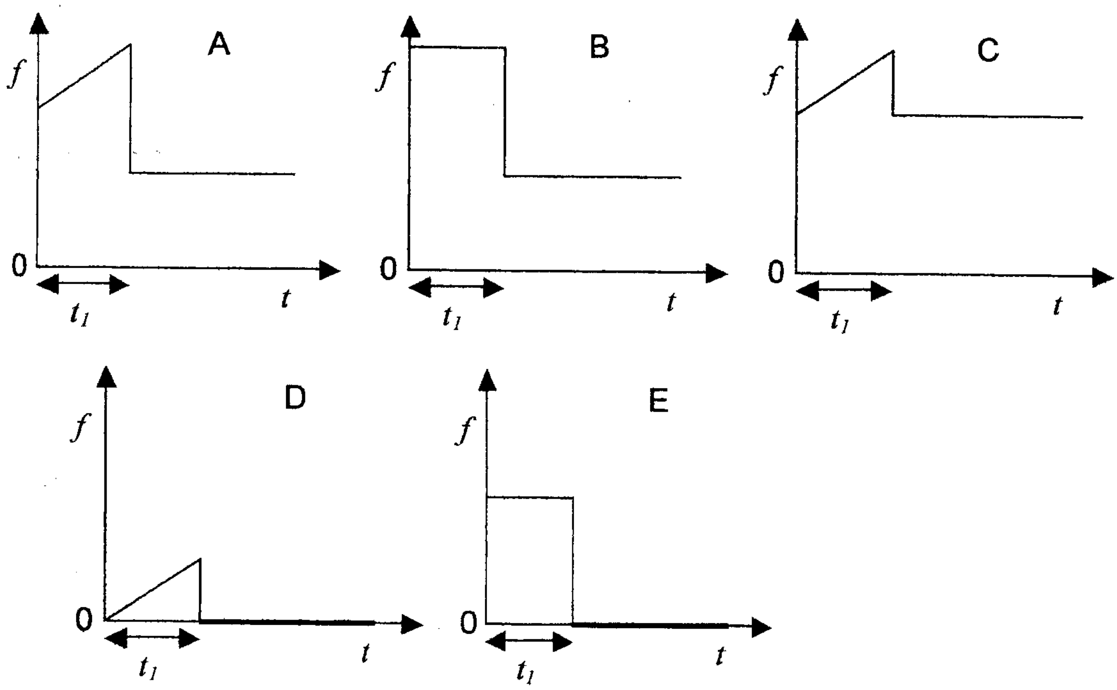
C A little shorter than the period for the phases for the moon

D About 1 year

3.



The speed v of a vehicle traveling along a straight level road is shown in the above graph. It starts from rest at time $t = 0$, accelerates uniformly until $t = t_1$ and then continues at constant speed. At all times the vehicle experiences a retarding force due to friction, which is proportional to its speed. The force f, which must be applied by the engine of the vehicle, is given by



A. B. C. D.

4. When a loud sharp sound is played in a room, the sound reverberates around the room until it gradually dies away. The reverberation time T for a room of volume V having surface area A is given by the expression

$$T = \frac{kV}{\alpha A}$$

Where k is a constant and α is a measure of the mean sound absorption by the surfaces.
If two rooms of identical shape and with walls of the same material, are tested for reverberation time, then for a room which is ten time longer, by what factor will the reverberation time be greater than for the smaller room?

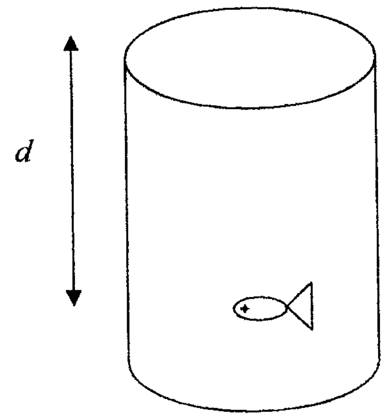
A. 1000

B. 100

C. 10

D. it depends upon the other dimensions of the rooms

5. A fish floats in water with its eye at the centre of an opaque walled full tank of water of circular cross section. When the fish look upwards, it can see a fish-eye view of the surrounding scene i.e. it is able to view the hemisphere of the scene above the water surface, and centred at the top of the tank. The diameter of the tank is 30 cm, and the critical angle for water is 48°. At what depth below the surface of the water, d, must the fish be floating?



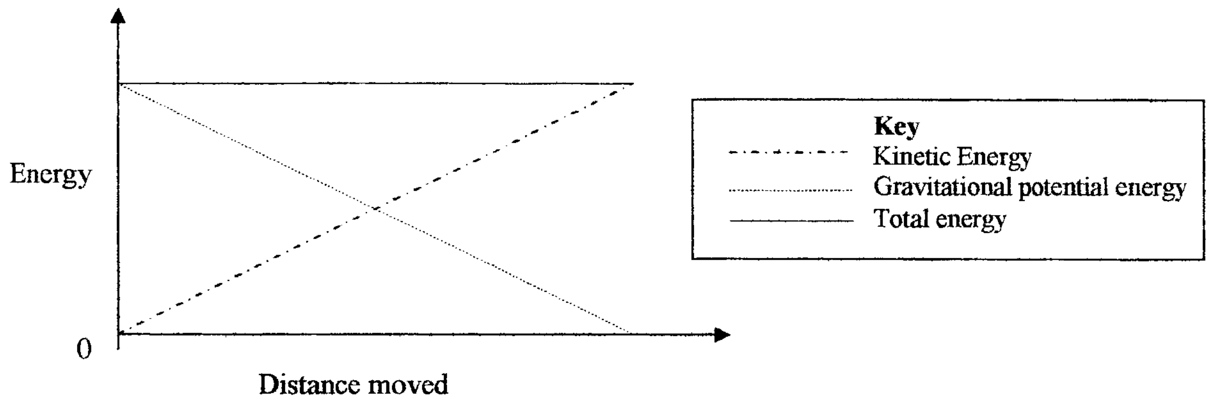
A. 16.7 cm

B. 13.5 cm

C. 11.2 cm

D. 10.0 cm

6. The graph below represents the kinetic energy, gravitational potential energy, and total energy of a moving block



Which best describes the motion of the block?

A Sliding down an incline with constant friction

B Falling at a constant velocity

C Accelerating on a flat horizontal surface

D Falling freely under gravity

7. The table shows how the resistive forces on a moving object vary with the object's speed. To what power of v is F proportional?

v/ms^{-1}	F/N
10	37
15	83
27	270
35	450

A. $v^{1/2}$

B. v

C. v^2

D. v^3

Section B: Written Answers

Question 8.

A fibre optic cable is used to transmit signals. When a short pulse of light passes along a fibre, it spreads out, which limits the rate of transmission of signals down the fibre.

a) Suggest two reasons why the pulse of light might spread out.

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____ [2]

b) A fibre of length 10.0 km is illuminated with red light from an led which is turned on and off repeatedly for equal amounts of time. The speed of the pulse of light ranges from 1.95×10^8 m/s to 2.05×10^8 m/s. Calculate the range of times taken for the pulse to travel down the fibre optic.

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____ [1]

c) What is the maximum frequency of the led so that the pulses arrive without overlapping?

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____ [3]

d) The wavelength the LED emits is 1310 nm in air. Calculate the frequency of the light used.

($c = 3.0 \times 10^8$ m/s)

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____ [1]

e) The frequency of light at the red end of the spectrum is 4×10^{14} Hz. Explain in what part of the spectrum the 1310 nm of part (d) is to be found.

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____ [2]

/9

Question 9.

A gas consists of particles moving around in random directions. Air molecules move with an average speed of 500 m/s at room temperature. In a balloon filled with hydrogen gas at the same room temperature, the hydrogen molecules would have the same average kinetic energy as the air molecules.

average relative molecular mass of air molecule = 29

relative molecular mass of hydrogen molecule = 2.0

a) Calculate the average speed of a hydrogen molecule.

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____ [3]

b) What is the average velocity of the hydrogen molecules in the balloon?

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____ [1]

c) Comment on how the speed of sound in hydrogen would compare with the speed of sound in air at the same temperature?

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____ [2]

d) If the mass of all the molecules of the hydrogen gas in the balloon is 1.0 g, calculate the sum of the kinetic energies of all the molecules in the balloon.

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____ [1]

e) If a balloon was filled with an identical number of air molecules at the same temperature, how would the sum of the kinetic energies of the air molecules compare with the value calculated in part (d) for hydrogen?

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____ [1]

f) If one of the hydrogen molecules was directed upwards from the surface of a planet which had no atmosphere, but was similar in size and mass to the earth and had the same gravitational field strength, to what height would the molecule go?
(assume that g is independent of height)

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____ [2]

g) How does this height, calculated in part (f), compare with the height reached by an air molecule directed upwards from the planet in an identical manner? (A numerical answer is not required)

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____ [1]

h) This height is not enough to get away from the earth's gravitational pull, and yet the hydrogen molecules at the top of the atmosphere do escape completely from the earth's gravitational field. Explain how this could be so.

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____ [2]

/13

Question 10.

a) The power dissipated as heat in a resistor in a circuit is given by $P = VI$. Show that this may also be expressed as $P = I^2 R$ and $P = \frac{V^2}{R}$.

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____ [1]

b) A student goes out to purchase an electric heater for his flat. The salesman says that, to get more heat, he should purchase a heater with a high resistance because $P = I^2 R$, but the student thinks that a low resistance would be best, because $P = \frac{V^2}{R}$. Explain who is correct.

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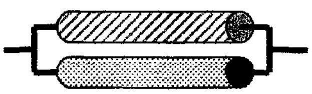
____ [2]

c) Copper is a better conductor than iron. Equal lengths of copper and iron wire, of the same diameter, are connected first in parallel, and then in series. A potential difference is applied across the ends of each arrangement in turn, and the p.d. is gradually increased from a small value until, in each case, one of the wires begins to glow. Explain this, and state which wire will glow first in each case.

Case 1



Case 2

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____ [4]

d) A surge suppressor is a device for preventing sudden excessive flows of current in a circuit. It is made of a material whose conducting properties are such that the current flowing through it is directly proportional to the fourth power of the potential difference across it. If the suppressor dissipates energy at a rate of 6 W when the applied potential difference is 230 V, what is the power dissipated when the potential rises to 1200 V?

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____ [3]

/10

Question 11.

When a metal rod is heated, it expands uniformly with temperature. The coefficient of linear thermal expansivity, α (alpha), is equal to the fractional increase in length per unit temperature rise.
If a rod of length ℓ expands by an amount $\Delta\ell$ when the temperature rises by $\Delta\theta$ in °C, α is given by,

$$\alpha = \frac{\Delta\ell}{\ell}\frac{1}{\Delta\theta}$$

a) What are the units of α?

____ [1]

A pendulum clock has a metal pendulum. The period of oscillation, T, of the pendulum is given by,

$$T = 2\pi\sqrt{\frac{\ell}{g}}$$

where ℓ is the length of the pendulum and g is the acceleration due to gravity. The period of the pendulum is exactly 1 second when the room temperature is such that the clock gives the correct time. On days when the room temperature is 15.0 °C the clock runs 5 s fast per day. When the room temperature is 30.0 °C, the clock runs 10 s slow per day.

b) When the clock gives the correct time, how many oscillations will occur in a day?

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____ [1]

c) For the two temperatures quoted, write down the number of oscillations that would occur in one day.

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____ [2]

d) Calculate the periods of the pendulum, T_{15}, and T_{30}, at the two temperatures.

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____ [2]

e) Calculate the corresponding values of lengths, ℓ_{15} and ℓ_{30}.

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____ [2]

f) Calculate the value of α for the metal of the pendulum.

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____ [3]

/11