PHYSICS CHALLENGE 2005

Total Mark	*Marks

Name	
School	
Town & County	

Time Allowed: One hour
Attempt as many questions as you can.
Write your answers on this question paper.
Marks allocated for each long question are shown in brackets on the right.
Allow roughly 10 minutes for Section A, 30 minutes for the first four questions of
Section B, and 20 minutes for the final question.
You may use any type of calculator.
$g=9.8\ ms^{-2}$

Section A: Multiple Choice.

Tick the box, which contains the correct answer to each question. One mark is awarded for each question.

1. What is the best estimate for the **weight** of a man?

A. 50 N	B. 25 kg	C. 65 kg	D. 750 N	E. 750 kg

2. Expanded polystyrene consists of cells of trapped air. This is a much better insulator than free air because moving air can transfer heat by

A. conduction	B. convection
C. radiation	D. expansion
E. contraction	

3. Two identical springs have unstretched lengths of 20 cm. A mass of 200 g is attached to the end of one spring and the spring lengthens to 25 cm. A mass of 80 g is hung on the end of the other spring. How long does it become?

A. 10 cm	B. 15 cm	C. 20 cm	D. 22 cm	E. 23 cm

4. A child who climbs up a pylon and touches a high voltage power cable is almost certain to be killed. Why can a bird perch safely on the same cable?

A. The bird stands on the cable and touches nothing else.	B. The bird's wings trap air between the feathers.
C. The bird's feet do not conduct.	D. Birds always stand on one foot.
E. The cable is covered by an insulator.	

5. The masses, M, and volumes, V, of four solid blocks, W, X, Y and Z, are measured, and the results are shown graphically in Figure 5; origin O.
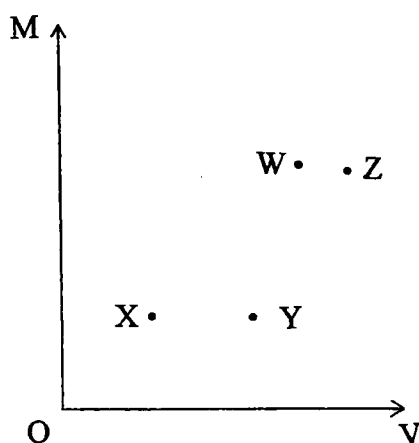

Figure 5

Which two blocks could be made of the same material?

A. W and Y	B. W and X	C. X and Y	D. W and Z	E. X and Z

6. A ray of light with a frequency of 5×10^{14} Hz is refracted from a vacuum into glass. A – E in Table 6 shows the likely frequency, wavelength and speed of the light within the glass block. Which is the correct row? (1 nm = 10^{-9} m)

Tick	Frequency / Hz	Wavelength / nm	Velocity / ms^{-1}
A	5.0×10^{14}	600	3.0×10^{8}
B	5.0×10^{14}	400	3.0×10^{8}
C	7.5×10^{14}	600	4.5×10^{8}
D	5.0×10^{14}	400	2.0×10^{8}
E	3.3×10^{14}	600	2.0×10^{8}

Table 6

7. A police officer directs a beam of radiation at a car. He detects a returning beam. The waves were:

A.ultra-violet	B. radio waves	C. gamma-rays	D. microwaves	E. X-rays

8. Iodine-131 is a radioactive substance with a half-life of 8 days. A sealed container holds 16 mg of iodine-131. How much iodine-131 will be left after 24 days?

A. 2 mg	B. 4 mg	C. 8 mg	D. 12 mg	E. 16 mg

9. During a Solar eclipse, the Moon just manages to block sunlight from reaching a part of Earth. This implies that the ratio Distance to Moon: Distance to Sun is equal to:

A. Radius of Moon: Radius of Sun	B. Radius of Earth: Radius of Sun
C. Radius of Sun: Radius of Moon	D. Radius of Sun: Radius of Earth
E. Radius of Moon: Radius of Earth	

10. A rabbit measures the acceleration of a falling carrot down a well. Rabbits use metres, but have their own unit of time – the thump (th). There are three thumps in one second. We would obtain the acceleration as 9.8 m/s^2. What would the rabbit measure?

A. 1.1 m/th^2	B. 3.3 m/th^2	C. 29 m/th^2	D. 29 m/th	E. 2.9 m/th^2

Section B: Written Answer

11. A girl stands 130 m away from a high wall. She claps her hands together at a steady rate such that 37 claps are made in 30 seconds; starting at time $t = 0$ and ending at $t = 30$ s Each clap, except the first, coincides with the echo of the one before. Calculate the speed of sound.
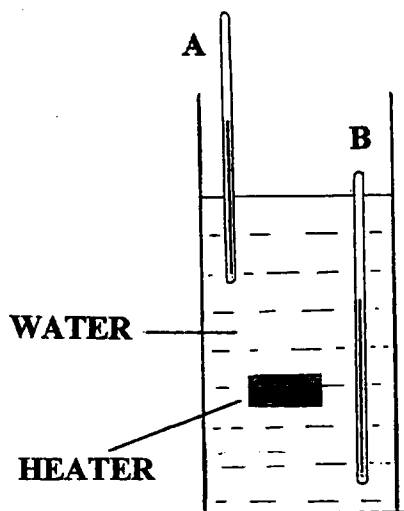
_____

_____

_____ [3]

12.

Figure 12

Figure 12 shows an electrical immersion heater in a cylinder of water. Two thermometers, A and B, are placed in the positions shown, and the heater is switched on, for a finite time, t_f. Sketch, on the same axes, graphs of the two temperatures, T_A and T_B, against time t in the space below.

[3]

13. (a) Calculate the kinetic energy of an asteroid of mass 8.0×10^{12} kg approaching the Earth at a speed of 4.0 km/s.

_____

_____

_____[3]

(b) Calculate the energy necessary to heat a lake of volume 2.0×10^8 m^3 from 15 °C to 100 °C, given that 1 kg of water requires 4200 J to raise its temperature by 1 °C and that the density of water is 1000 kg/m^3. Assume there is no evaporation.

_____

_____

_____[3]

(c) Calculate the gravitational potential energy gained by a square continent of area 3500 km × 3500 km, and depth 10.0 km, made of rock of density 2500 kg/m^3, when it is raised through a height of 1.00 km; the gravitational field strength being 10.0 N/kg.

_____

_____

_____[3]

(d) From your answers to (b) and (c) determine, by calculation, the effect of the asteroid in (a) hitting (i) a lake with 1000 times the volume of water in (b) and (ii) the continent in (c).

_____

_____

_____[2]

14. The device in Figure 14 is an accelerometer which is fitted to a car. It consist of a spherical ball, mass 0.09 kg, attached to a pointer which can move horizontally against a fixed scale that gives the acceleration of the car; O indicates zero acceleration. On each side of the ball are attached identical springs, S_1 and S_2, that are fixed at their ends. The device is enclosed in a rigid transparent housing.
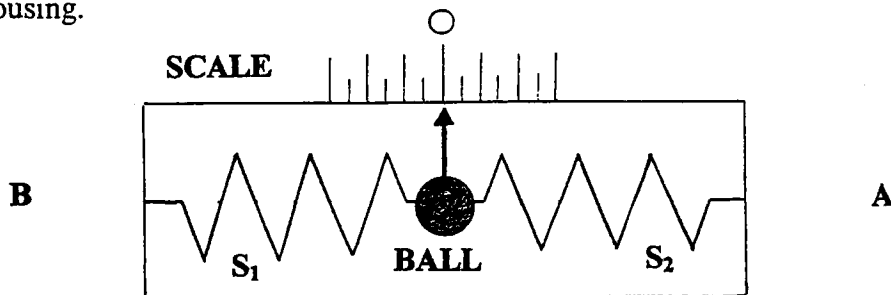

Figure 12

The car accelerates towards A.

(a) In which direction does the pointer move?

_____

_____ [1]

(b) Explain why does it moves in this direction.

_____

_____

_____ [2]

Each spring requires a 0.4 N force to extend or compress it by 1.0 cm.

(c)   What steady force is needed to move the pointer 2.0 cm from O?

_____

_____ [2]

(d)   What steady acceleration is required to move the pointer in (c)?

_____

_____

_____ [1]

The car starts from rest at time $t = 0$ and travels along a straight road. The accelerometer readings are recorded in Table 14.

Time / s	Acceleration / m/s^2
0.00 – 3.00	11.00
3.00 – 4.50	7.00
4.50 – 7.00	0.00

Table 14

(e)   How fast is the car travelling after 7.00 s?

_____

_____

_____ [1]

(f)   How far does the car travel in the first 7.00 s?

_____

_____

_____

_____

_____ [3]

(g)   Aeroplanes are fitted with three accelerometers as part of their navigation equipment. Why are three accelerometers needed?

_____

_____ [2]

15. Any object that is isolated electrically from earth can store electric charge. For example, you have probably experienced the build up of static charge on your clothes on a cold dry day.

Figure 15(a) shows a plate, X, electrically isolated from another plate, Y, directly below it. The lower plate is earthed and a cell is used to charge up the top plate, X. The two plates form a device known as a capacitor.
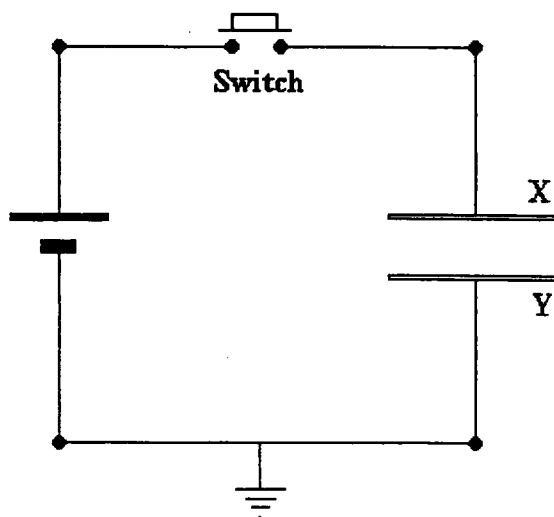

Figure 15(a)

(a) Indicate, by arrows, on the diagram the direction in which **electrons** move onto and off the plates when the switch is closed. [1]

(b) The amount of charge capable of being stored on the X plate gets larger as you increase the voltage of the cell; this charge is proportional to the charging voltage. The ability of the X plate to store charge is called its *capacitance*. This quantity measures the extra charge stored each time the voltage is increased by 1 V. State below the unit of capacitance.

_____ [1]

(c) A small memory card takes a 20 mA current from a 12 V supply. Its battery is connected in parallel with the capacitor, which quickly charges up to 12 V. The X plate has 0.07 units of capacitance, Figure 15(c).
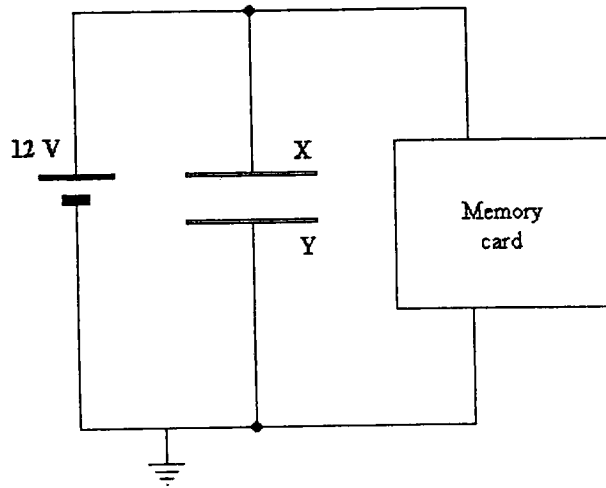

Figure 15(c)

(i) Calculate the resistance of the memory card. [1]

_____

_____

(ii) Calculate the charge stored on the X plate. [2]

_____

_____

(iii) The battery is removed for replacement. It must be changed before the capacitor 'runs out' of charge, or else the data saved on the card will be lost. Estimate the time required to change the battery before the data is lost. [2]

_____

_____

(iv) Give two reasons why the time you have calculated in (iii) is only an estimate. In each case indicate if your result is too long or too short.

_____

_____

_____

_____ [3]