Mark Scheme Physics Challenge 2005

Please award marks as indicated below. Equivalent valid reasoning should gain equal credit to the solution presented here. Schools may give 'error carried forward' marks where an incorrect answer is used as part of the data needed for a subsequent question, providing that the resulting final answer is not plainly ridiculous.

If **incorrect units** are used more than once in the paper, one mark should be deducted from the pupil's total. If an inappropriate number of **significant figures** are given, more than once in final answers on the paper, then one mark should be deducted from the pupil's total.

Certain points are worthy of special credit, and have been given '**star marks**' (*). These are counted together with the normal marks in each student's total. The staff at the Olympiad office would be grateful if the two boxes on the front of the paper were filled in. The first box should contain the student's total mark (star marks included). The second box should contain the number of star marks the pupil earned.

Section A: Multiple Choice

One mark, or one star mark, is to be awarded for each question.

1. D	2. B	3. D	4. A	5. B *
6. D *	7. D	8. A *	9. A	10. A *

Section B: Written Answer

11. Return distance travelled by sound = 260m [1]
Time for one return journey = 30 s ÷ 36 = 0.83 s [1]
Speed = Distance ÷ Time = 260 m ÷ 0.83 s = 313 m/s = 3.1×10^2 m/s [1]

Question Total *3*

12. Thermometer A trace begins to rise straight away. [1]
B begins to rise after a time delay, and rises more slowly than A. [1*]
T_A and T_B reach the same final value after a time greater then t_f. [1*]

Question Total *3 including 2**

13. (a) Kinetic energy = $mu^2/2$ [1]
$= \frac{1}{2}(8.0 \times 10^{12})(4 \times 10^3)^2$ J [1]
$= 6.4 \times 10^{19}$ J [1]

(b) Mass = volume × density = 2.0×10^{11} kg [1]
Energy to raise temperature by 1°C = $2.0 \times 10^{11} \times 4200 = 8.4 \times 10^{14}$ J [1]
Energy to raise temperature by 85°C = $85 \times 8.4 \times 10^4 = 7.14 \times 10^{16}$ J [1]

(c) Volume = 1.225×10^5 km^3 = 1.225×10^{17} m^3 [1]
Mass = volume × density = 3.06×10^{20} kg [1]
Gravitational P.E. = $10 \times 3.06 \times 10^{20} \times 1000 \approx 3.1 \times 10^{24}$J [1*]

(d)

(i) Temperature rise = $6.4 \times 10^{19} / (8.4 \times 10^{14} \times 10^{3}) \approx 76$ °C [1*]

(ii) If a continent was hit, it could only rise uniformly by about 2.1 cm. [1*]

Question Total *11 including 3**

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14 (a) Towards B [1]

(b) Mass must be given an acceleration towards A. An 'unbalanced' forwards force is needed, so S_2 must be stretched and S_1 compressed. [1] [1]

(c) For each spring, magnitude of force is 0.8 N, S_1 compressed, S_2 extended, so total force = 1.6 N [1]

(d) Acceleration = Force ÷ Mass = 1.6 ÷ 0.09 = 17.8 m/s^2 ≈ 18 m/s^2 [1]

(e) Velocity change = 3 s × 11 m/s^2 + 1.5 s × 7 m/s^2 = 43.5 m/s. [1]

(f) In first 3s, average speed = (33+0)÷2 = 16.5 m/s
Thus distance travelled = 16.5 m/s × 3 s = 49.5 m [1]
In next 1.5 s, average speed = (33+43.5)÷2 = 38.3 m/s
so distance = 38.3 m/s × 1.5 s = 57.4 m [1]
Total distance = 49.5 m + 57.4 m + 2.5 × 43.5 ≈ 216 m [1*]

(g) Acceleration is in three directions. This requires three components, e.g. up/down, North/South and East/West [1]
Accelerations in each direction are independent so one accelerometer is needed for each direction. *(allow other sensible suggestions)* [1*]

Question Total *12 including 2**

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15 (a) From the upper, X, plate to the cell and from cell onto Y plate [1]

(b) Coulombs per volt (C/V) [1]

(c) (i) Resistance = 12 V ÷ 0.02 A = 600 Ω = 6.0×10^2 Ω [1]

(ii) Charge = 0.07 × 12 V [1]
= 0.84 C ≈ 0.8 C [1*]

(iii) e.g. time = charge ÷ current = 0.8 C ÷ 0.02 A = 4.0×10 s [1*]
Current assumed to be constant. [1]

(iv) *One mark for suggestion, one * mark for explanation, up to a maximum of 4*
e.g. Memory will fail long before voltage reaches 0 V, [1*]
Too high. [1]
e.g. Current drops as charge on plate falls, [1*]
falls to low [1]
Other sensible answers acceptable.

Question total *11 including 4**

Total marks on paper **50 including 15***