AS CHALLENGE PAPER 2013 SOLUTIONS

Setting the paper

It is intended that the paper is taken on Friday 15th March 2013 in exam conditions. However, if this date is not possible, any date during the period 11th to 22nd March will be acceptable.

Please see the front of the exam paper for further information about setting the paper.

Awards

The award scheme is as follows:

Award	Mark range
Participation	0 - 13
Bronze	14 – 25
Silver	26 – 37
Gold	38 – 50

Marking

The mark scheme is prescriptive, but markers must make some allowances for alternative answers.

A value quoted at the end of a section must have the units included. Candidates lose a mark the first time that they fail to include a unit, but not on subsequent occasions except where it is a specific part of the question.

Significant figures are related to the number of figures given in the question. A single mark is lost the first time that there is a gross inconsistency (more than 2 sf out) in the final answer to a section.

Ecf: this is allowed in numerical sections provided that unreasonable answers are not being obtained. Ecf cannot be carried through for more than one section after the first mistake (e.g. a mistake in section (d) can be carried through into section (e) but not then used in section (f)).

owtte: “or words to that effect” – is the key physics idea present and used?

Section A: Multiple Choice

1. **D**
2. **D**
3. **B**
4. **C**
5. **C**

6. **A**
7. **C**
8. **B**
9. **C**
10. **A**

There is 1 mark for each correct answer.

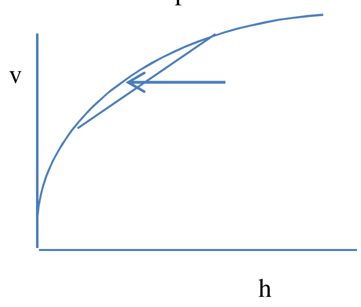
Maximum 10 marks

Multiple Choice Solutions

Qu. 1 Newton's Third Law applies and the force of body A on body B is equal and opposite to the force of body B on body A. This is rather less clearly given as Action and Reaction are equal and opposite. Here A and B form a Newton III pair (of bodies).

Qu. 2 The current flow is the same along the wire, so using I^2R for the power generated (which will cause the heating) means that a point with a lower resistance will generate less power and a point along the wire with a greater resistance will produce more heating.

Qu. 3 We want a relation between speed and distance fallen. This can be from $v^2 = u^2 + 2as$ or from $\frac{1}{2} mv^2 = mgh$. So $v \propto \sqrt{h}$ and if we find the average of two speed values on the graph then that corresponds to an h which is nearer the smaller speed value *i.e.* the top of the window.



Qu. 4 Tabulate

colls	Ke	v
1	½	√1/2
2	¼	½
3	1/8	√1/8
4	1/16	¼
5	1/32	√1/32
6	1/64	1/8

Qu. 5 $\frac{1}{2} mv^2 = eV$ The potential is given to 2 sig fig so that limits the answer to 2 sig fig.

Qu. 6 The moments are balanced, but as the right hand side is further from the pivot the left hand side must compensate with a greater mass for it to balance.

Qu. 7 The GPE is decreasing as the distance increases, so the must be a vertical falling. Meanwhile the KE increases steadily and the total energy is conserved so that there is no dissipation of the energy taking place to produce heat.

Qu. 8 Calculate the frequency as speed/ wavelength, multiply by Planck's constant to get the energy of a single photon. The reciprocal gives the number of photons per joule and we require the number of photons per mJ.

Qu. 9 By observation, if the slopes were tilted so that one was vertical, the masses would slip towards that side. So as it is not symmetric and the masses are identical and there is no friction, then the masses cannot be in equilibrium.

Qu. 10 Energy of a single electron being driven through a potential of 1.5 V (J/C) must be 1 eV where e is the charge on an electron.

Section B: Written Answers

Question 11.

a) The formula will not give the right potential with any other unit ✓
Or the formula is dimensionally inhomogeneous / units on left and right are not the same
Or the 4 and the 2 should have units attached (like intercept and gradient)

Or equivalent statement but not "we always use seconds"

b) V α I for a range of currents or V/I is constant ✓
Or R is constant (independent of temperature)

c) V = 4 + 2 x 6 = 16 V ✓

d)
  i. 2.0 A (unit needed) ✓
  ii. I = (4 + 2t) / 8 = 0.5 + 0.25 t ✓
Must have "I =" not just the right hand part.

e) Straight line graph through (0, 0.5) (not the origin)
<u>and</u> through the point (6, 2.0) ✓

f) Area under graph ✓

= 0.5 x 6 + ½ x (2.0 – 0.5) x 6 = 3 + 4.5 = 7.5 C ✓

g) Rising curve (quadratic) passing through the point (6, 32) ✓
through (0, 2) and not the origin ✓

h) 50 W = $(4 + 2t)^2$ /8 ✓
t = 8 s ✓

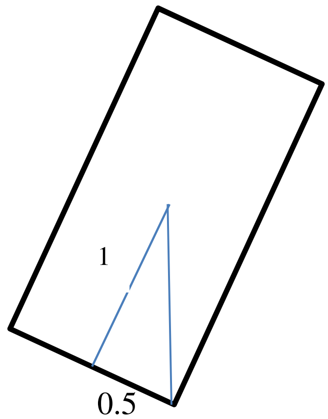
Total 12

Question 12.

a) Block shown in diagonal position with the centre of gravity directly above the bottom corner ✓

KE to GPE as centre of gravity rises ✓

b)



Centre of mass rises from 1 m high to ½ √5 high ✓

So $\frac{1}{2} mv^2 = mgh$ ✓

And $\frac{1}{2} v^2 = g \frac{1}{2} (\sqrt{5} - 2)$ change in height of Cof G ✓

So $v^2 = g (\sqrt{5} - 2)$

And $v = (g (\sqrt{5} - 2))^{1/2}$

Which evaluates to $v = 1.5\ m\ s^{-1}$ ✓

c) The longer time scale must be such that the time for deceleration must be short compared to the time for the block to rise to its toppling position, (owtte) ✓

Because once it starts rising from the floor of the truck it is becoming more unstable and easier to turn over even by a very small deceleration.

The shortest time is not so clear but would be such as to not cause deformations of different parts of the block which would be dissipated as heat (all parts of the wardrobe should be in equilibrium).

A suitable answer would be not so short a time as to cause the wardrobe to "shake" or vibrate owtte ✓

Total 8

Question 13.

a) Speed of groove rotating = 33⅓/60 x 2π x 14.6

mark for 33⅓/60 ✓

= 50.96 = 51 cm s^{-1} ✓

= 0.51 m s^{-1}

b) Use of $v = f\lambda$ ✓

λ = 0.51/8,000 = 6.4 x 10^{-5} m ✓

[= 64 microns (width of a human hair)]

c) Since circumference is proportional to radius, 2/5 of the radius means 2/5 of the speed

(note that the rate of rotation is fixed at 33⅓ rpm),

and hence the wavelength will be 2/5 - this is the key point - ✓

i.e 2.6 x 10^{-5} m correct answer (with ecf) obtains the mark

d) Wavelength in air = 0.041 m or 4.1 cm ✓

e) Although the speed of sound will be different and the wavelength will be different, the frequency will remain the same.

If the frequency changed there would be an accumulation (or loss) of energy of waves as the wave peaks accumulated at some point in space **owwtte** ✓
Some comment is needed for the mark.
(In the record groove and in air the frequency is the same).

Total 7

Question 14.

a) ΔE = 75 x 4,200 ✓

= 315,000 J or J/ ^{o}C ✓ a unit needed

b) 240 / 315,000 (^{o}C/second) ✓

7.6 x 10^{-4} ^{o}C/second ✓

Or inverse 1312 seconds/ ^{o}C the units must make the answer clear

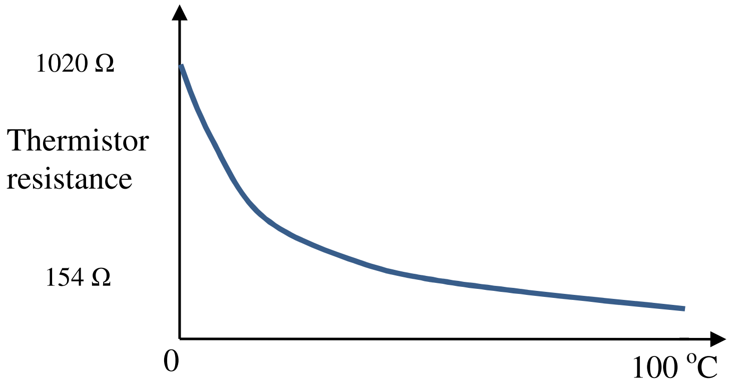
c) For 2 ^{o}C Δt = 2 / 7.6 x 10^{-4} = 2,600 seconds ✓

(= 44 minutes)

Total 5

Question 15.

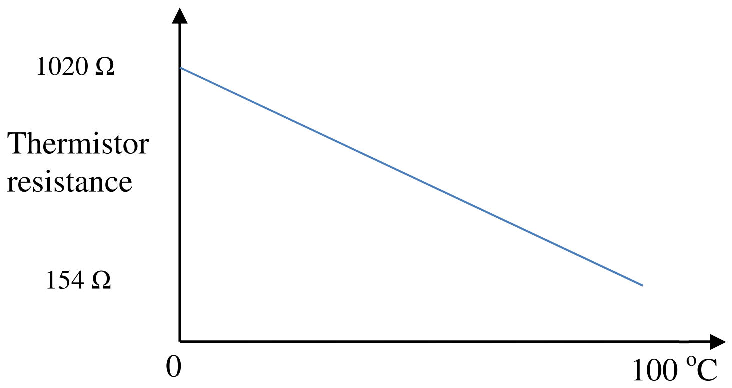
a)



Temperature measured with a mercury thermometer

Resistances marked on the y axis ✓
Thermistor resistance curve concave as shown ✓

b)



Temperature measured with a thermistor thermometer

Resistances marked on the y axis ✓
Straight line for linearized scale ✓

c) Change of resistance/change of temp $= (1020 - 154)/100$
$= 8.66\ \Omega\ {}^{o}C^{-1}$ ✓

d) 1020 Ω to 292 Ω is a change of 728 Ω ✓
(No mark for using 154 Ω here)

e) Body Temperature = 728/8.66
= 84 °C ✓

(measured on the thermistor scale)
The temperature appears very high, because we are measuring it on a scale which is non-linear compared to the mercury scale with which we are familiar
owtte ✓
(The mercury scale is nonlinear compared to the gas scale of temperature, but there is a small difference between the scales there).

Total 8

END OF SOLUTIONS