1996

Don Easton

(j) A pleasing number of candidates got this right. It was a shame that a number did not read the question carefully and talked about increasing frequency.

(k) Most got this right, but a significant number gave the rather puzzling answer of "c" for X.

(l) Most candidates had the right idea but some were not able to explain clearly enough to gain both marks.

PHYSICS MARKING SCHEDULE 1996

The following formulae may be of use to you:

$\Delta p = Ft$	$y = A\sin(\omega t + \phi)$
$F_c = \frac{mv^2}{r}$	$v = A\omega\cos(\omega t + \phi)$
$m_1x_1 = m_2x_2$	$a = -A\omega^2\sin(\omega t + \phi)$
$m_1x_1 = m_2(d - x_1)$	$E = \frac{1}{2}CV^2$
$L = mvr$	$V_{rms} = \frac{V_0}{\sqrt{2}}$
$L = I\omega$	
$\theta = \omega_0 t + \frac{1}{2}\alpha t^2$	$X_L = \omega L$
$\omega = \omega_0 + \alpha t$	$X_c = \frac{1}{\omega C}$
$\omega^2 = \omega_0^2 + 2\alpha\theta$	

Question 1: Dodgems and the Log Flume (18 marks)

(a) $p = mv$
$= (170 + 85) \times 3.0$
$= 770\ (765)$ kg m s^{-1}
Formula and substitution *(1 mark)*
Answer *(1 mark)*

(b) It must stop on impact *(1 mark)*
because momentum must be conserved *(1 mark)*

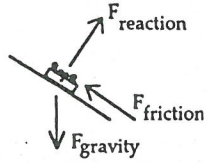
(c) $E_K = \frac{1}{2} m v^2$
$= 0.5 \times 255 \times 3.0^2$
$= 1147.5$
$= 1100\ (1150)$ J
Formula and substitution *(1 mark)*
Answer *(1 mark)*

(d) Converted to heat *(1 mark)*

(e) (i) E_K(gained) = E_K(lost)
$\frac{1}{2}mv^2 = mgh$
$\frac{1}{2} \times 311 \times v^2 = 311 \times 9.80 \times 8.00$
$\Rightarrow v = 12.522$
$= 12.5\ (13)$ m s^{-1}
Conservation of energy concept *(1 mark)*
Formulae and substitution *(1 mark)*
Answer *(1 mark)*

(ii) Some of the energy would be lost as heat.
(Friction would slow the log down.) *(1 mark)*

(f)



Correct direction and label *(1 mark each)*

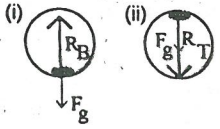
(g)

Correct direction *(1 mark)*

(h) $\Delta p = Ft$
$\Rightarrow mv = Ft$
$311 \times 11.5 = F \times 1.50$
$\Rightarrow F = 2384.3$
$= 2380$ N
Correct concept *(1 mark)*
Formula and substitution *(1 mark)*
Answer *(1 mark)*

Question 2: The Roller Coaster and Bumper Boats (18 marks)

(a) (i) (ii)



Correct direction *(1 mark each)*

(b) $F = F_g + R_T$
Formula correct or consistent with diagram *(1 mark)*

(c) $F = \frac{mv^2}{r}$
At minimum speed R_T is zero
$\Rightarrow mg = \frac{mv^2}{r}$
$\Rightarrow v = \sqrt{9.8 \times 4.77}$
$= 6.84$ m s^{-1}
Recognition that R_T is zero *(1 mark)*
Recognition that F is centripetal *(1 mark)*
Answer *(1 mark)*

(d) $m_b x = m_p(d - x)$
$52 \times x = 58\ (0.45 - x)$
Concept *(1 mark)*
Substitution *(1 mark)*

(e) The boat will translate in the direction of the jump and rotate about the centre of mass of the system (in an anticlockwise direction).
The boat will translate *(1 mark)*
The boat will rotate *(1 mark)*
Directions are correct *(1 mark)*

(f) $L = mvr$
$= 58 \times 2.0 \times (0.45 - 0.23727)$
$= 24.677$
$= 25\ (24.7)$ kg m^2 s^{-1}
Correct r *(1 mark)*
Formula and substitution of m and v *(1 mark)*
Answer (consequential allowed) *(1 mark)*

(g) $\alpha = \frac{\Delta\omega}{t}$
$= \frac{3.16}{6.0}$
$= 0.5267$
$= 0.53\ (0.527)$ rad s^{-2}
Formula and substitution *(1 mark)*
Answer *(1 mark)*

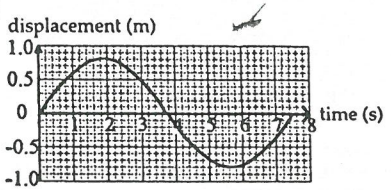
(h) $\tau = I\alpha$
$\Rightarrow I = \frac{4.11}{0.5267}$
$= 7.8033$
$= 7.8\ (7.80)$ kg m^2
Formula and substitution *(1 mark)*
Answer *(1 mark)*

Question 3: Oscillations (14 marks)

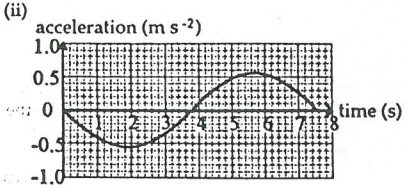
(a) $\omega = 2\pi f$
$= \frac{2\pi}{7.5}$
$= 0.83776$
$= 0.84\ (0.838)$ rad s^{-1}
Formula and substitution *(1 mark)*
Answer *(1 mark)*

(b) $a = A\omega^2$
$= 0.80 \times 0.83776^2$
Formula *(1 mark)*
Substitution *(1 mark)*

(c) (i)



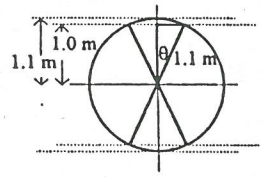
(ii)



Both curves sinusoidal *(1 mark)*
Period is 7.5s *(1 mark)*
Maximum displacement correct *(1 mark)*
Maximum acceleration correct *(1 mark)*
Graphs show opposite phase *(1 mark)*
Graphs drawn with reasonable care *(1 mark)*

(d) Because the amplitude decreases. *(1 mark)*

(e)



$\theta = \cos^{-1}\frac{1.0}{1.1}$
$= 24.62°$
$= 0.4297$ rad
$\theta = \omega t$
$\Rightarrow t = \frac{0.4297}{0.83776}$
$= 0.5129$ s
total time $= 4 \times t$
$= 2.0517$
$= 2.1\ (2.05)$ s
Triangle correct (or correct formula) *(1 mark)*
θ correct *(1 mark)*
Time correct *(1 mark)*

Question 4: Waves (16 marks)

(a) The incident wave will be reflected and travel back through itself. *(1 mark)*

(b) Transverse. *(1 mark)*

(c) Strength of the wind
Rigidity of tower
Frequency of wind gusts / natural frequency
Height / diameter of tower.
Each of two correct answers *(1 mark)*

(d) They are both transverse and longitudinal. *(1 mark)*

(e) Base isolation keeps the building stationary during horizontal movement of the earth caused by the transverse wave.
Buffers keep the building stationary during vertical movement of the earth caused by the longitudinal wave.
Earthquake proofing linked to prevention of movement of the building. (1 mark)
Base isolation and buffers linked to the correct type of wave. (1 mark)

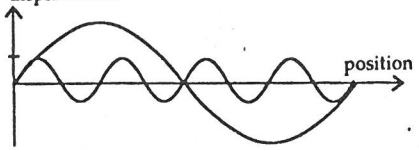
(f) Because the forced oscillation frequency of the earthquake is very different from the natural frequency of the tower. (1 mark)
There will never be resonance. (1 mark)

(g) B is microwave (and A is radio). (1 mark)
Because the wavelength of microwaves is less than the wavelength of radio waves. (1 mark)

(h) Longer wavelength waves are diffracted further and therefore the radio wave is more likely to be picked up.
Recognition of the principle (1 mark)
Correct deduction (1 mark)

(i) Their frequencies are too different. (1 mark)

(j) displacement



Correct amplitude (1 mark)
Correct wavelength (1 mark)

Question 5: Interference (14 marks)

(a) $c = f\lambda$

$\Rightarrow f = \dfrac{3.0 \times 10^{8}}{6.0 \times 10^{-7}}$

$= 5.0 \times 10^{14}$ Hz

Formula and substitution (1 mark)
Answer (1 mark)

(b) They must be out of phase by ½ cycle. (1 mark)

(c) 5½ cycle phase difference means 5 wavelengths travel difference. (1 mark)

$\therefore d = 5 \times 6.0 \times 10^{-7}$

$= 3.0 \times 10^{-6}$ m (1 mark)

(d) Distance $= 2 \times$ thickness

$\Rightarrow$ thickness $= 1.5 \times 10^{-6}$ m (1 mark)

(e) Black (dark, no colour). (1 mark)

(f) Film thickness not uniform. (1 mark)

(g) Rate of change of thickness not constant. (1 mark)

(h) (i) Width of each fringe would increase. (1 mark)
(ii) Fringes would not be circular. (1 mark)

(i) Frequency (or wavelength). (1 mark)

(j) Red (1 mark)
Because light from a retreating source has a longer wavelength. (1 mark)

Question 6: Electricity Supply In New Zealand (34 marks)
Generation (12 marks)

(a) From gravitational potential energy to kinetic energy. (1 mark)

(b) Area $= 0.50 \times 0.50$

$= 0.25$ m² (2500 cm²) (1 mark)

(c) B and D (1 mark)
Because the face of the loop is perpendicular to the flux. (1 mark)

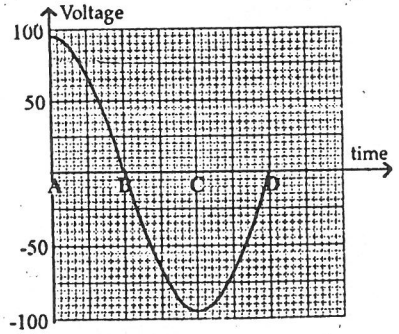
(d) $\phi = BA$

$= 1.2 \times 0.25$

$= 0.30$ Wb

Area changed to square metres (1 mark)
Formula and substitution (1 mark)
Answer (1 mark)

(e)



Zero at B and D (1 mark)
+ maximum at A and - maximum at C (1 mark)
Amplitude correct (1 mark)

(f) $V_{rms} = \dfrac{V_{max}}{\sqrt{2}}$

$= 1768$

$= 1800$ (1770) V

Formula and substitution (1 mark)
Answer (1 mark)

Distribution (11 marks)

(g) Copper (1 mark)
Because it has the lowest resistivity. (1 mark)

(h) Aluminium has the least density. (1 mark)

(i) $\Delta r\% = \dfrac{0.5}{49.5} \times 100$

$= 1.020$

$= 1\%$ (1 mark)

(j) $\Delta R\% = \Delta L\% + \Delta A\%$

$= 5\% + 2 \times 1.020\%$

$= 7\%$

Concept of adding percentage uncertainties (1 mark)
Recognition that $\Delta r\%$ must be doubled (1 mark)

(k) 7% of 0.7437394 = 0.05206

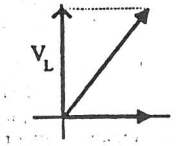
$R = 0.74 \pm 0.05$

Absolute uncertainty calculated (1 mark)
Absolute uncertainty 1sf (1 mark)
Resistance same dp as uncertainty (1 mark)

(l) Less energy is lost as heat (1 mark)
because the current is lower. (1 mark)

Use (11 marks)

(m)



Direction (1 mark)
Length (1 mark)

(n) $V_{SUPPLY}^2 = V_L^2 + V_R^2$

$V_L^2 = 250^2 - 150^2$

Recognition that Pythagoras must be used (1 mark)

(o) $V = IR$

$\Rightarrow 150 = I \times 14.5$

$\Rightarrow I = 10.345$

$= 10$ (.3) A

Formula and substitution (1 mark)
Answer (1 mark)

(p) $V_L = XI_L$

$\Rightarrow 200 = X \times 10.345$

$\Rightarrow X = 19$ (.3) Ω

Formula and substitution (1 mark)
Answer (1 mark)

(q) A capacitor (1 mark)
whose reactance is the same as that of the inductor. (1 mark)

(r) The reactance of the inductor will increase. (1 mark)
The voltage across the resistor will decrease. (1 mark)

Question 7: The Electrical System of a Car (14 marks)
The Starter Motor (10 marks)

(a) $\dfrac{1}{R_{circuit}} = \dfrac{1}{R_{bulb}} + \dfrac{1}{R_{bulb}}$

$\Rightarrow R_{circuit} = 0.5 \times 4.22$

$= 2.11\ \Omega$

$R_{total} = R_{circuit} + R_{internal\ resistance}$

$= 2.11 + 0.0400$

Parallel resistance (1 mark)
Total resistance (1 mark)

(b) $EMF = I_{circuit} \times R_{total}$

$\Rightarrow I_{circuit} = \dfrac{12.0}{2.15}$

$= 5.5814$

$\Rightarrow I_{bulb} = ½ I_{circuit}$

$= 2.791$

$= 2.79$ A

Source current correct (1 mark)
Bulb current is ½ source current (1 mark)

(c) To allow the required large current to flow. (1 mark)

(d) If connected in series the resistance of the bulbs would limit the current. (1 mark)

(e) $V_{terminal} = EMF - V_{internal\ resistance}$

$V_{in\ res} = Ir$

$= 61.5 \times 0.0400$

$= 2.46$ V

$\Rightarrow V_{terminal} = 12.0 - 2.46$

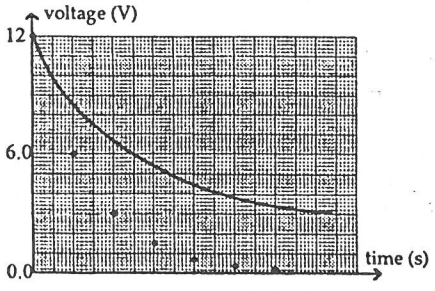
Voltage relationship (1 mark)
Substitution (1 mark)

(f) A drop in terminal voltage means a drop in bulb voltage. (1 mark)
A drop in voltage across the bulbs means less power (current). (1 mark)

The Distributor (4 marks)

(g) $Q = VC$
$= 12 \times 0.20 \times 10^{-6}$
$= 2.4 \times 10^{-6}$ C
Formula and substitution *(1 mark)*
Answer *(1 mark)*

(h)



Voltage intercept at 12 V *(1 mark)*
Curve indicates a longer discharge time *(1 mark)*

Question 8: Cosmic Rays (24 marks)

(a) $d = vt$
$\Rightarrow t = \dfrac{4600}{2.97 \times 10^{8}}$
$= 1.55 \times 10^{-5}$ s
Formula and substitution *(1 mark)*
Answer *(1 mark)*

(b) When a particle is travelling close to the speed of light, time, relative to that on earth, travels more slowly.
Recognition that relativity is the principle *(1 mark)*
Recognition that there is either a time (mass) increase or distance decrease. *(1 mark)*

(c) $c = f\lambda$
$\Rightarrow \lambda = \dfrac{3.00 \times 10^{8}}{5.379 \times 10^{14}}$
$= 5.5772 \times 10^{-7}$
$= 5.58 \times 10^{-7}$ m
Formula and substitution *(1 mark)*
Answer *(1 mark)*

(d) $E = hf$
$= 6.63 \times 10^{-34} \times 5.379 \times 10^{14}$
Formula *(1 mark)*
Substitution *(1 mark)*

(e) $E = hf$,
$c = f\lambda$
$\Rightarrow \lambda = \dfrac{hc}{E}$
$= \dfrac{6.63 \times 10^{-34} \times 3.00 \times 10^{8}}{3.16 \times 10^{-19}}$
$= 6.29 \times 10^{-7}$ m
$\Rightarrow$ orange
Both formulae used *(1 mark)*
Substitution and answer *(1 mark)*
Colour *(1 mark)*

(f) Second excited energy state $= -1.51 \times 10^{-18}$ J
First excited energy state $= -1.86 \times 10^{-18}$ J
Difference between ground and first correct *(1 mark)*
Difference between first and second correct *(1 mark)*
Energies increase from the ground state *(1 mark)*

(g) L = 2 *(1 mark)*

(h) $\dfrac{1}{\lambda} = 1.097 \times 10^{7}\left(\dfrac{1}{1^2} + \dfrac{1}{2^2}\right)$
$\Rightarrow \lambda = 1.215 \times 10^{-7}$ m
Formula and substitution *(1 mark)*
Answer *(1 mark)*

(i) In the ultra-violet (or above) range. *(1 mark)*

(j) The wavelength would appear to be shorter because of the Doppler effect. *(1 mark)*

(k) a = 1 *(1 mark)*
b = 1 *(1 mark)*
X is a proton (or hydrogen nucleus) *(1 mark)*

(l) It can be used to determine the age of dead organic material. *(1 mark)*
By relating the current activity of the sample to the known activity of living organic matter the half-life of C-14 can be used to find the sample's age. *(1 mark)*

* stockings
* advice
* friends
* impolite