1996 HIGHER PHYSICS SOLUTIONS

PAPER II

QUESTION 1

(a) (i) $V^2 = U^2 + 2as$
$V^2 = 0^2 + 2 \times (-9{\cdot}8) \times (-3{\cdot}15)$
$V^2 = 61{\cdot}74$
$V = \underline{\underline{7{\cdot}86\ \text{m s}^{-1}}}$

(ii) $V^2 = U^2 + 2as$
$0^2 = U^2 + 2 \times (-9{\cdot}8) \times (+1{\cdot}75)$
$U^2 = 34{\cdot}3$
$U = \underline{\underline{5{\cdot}86\ \text{m s}^{-1}}}$

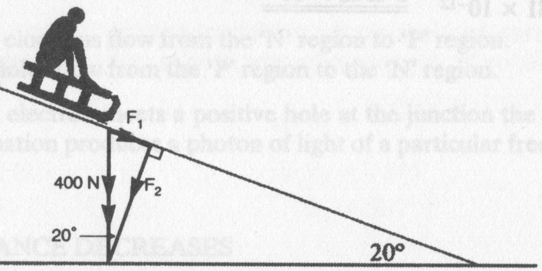
(b) (i) Mean = $\underline{\underline{1{\cdot}74\ \text{m}}}$

(ii) Random error $= \dfrac{1{\cdot}78 - 1{\cdot}71}{6}$

$= \dfrac{0{\cdot}07}{6}$

$= \underline{\underline{0{\cdot}01\ \text{m}}}$

QUESTION 2



(a) (i) We require F_1

$\sin 20 = \dfrac{F_1}{400}$

$F_1 = 400 \sin 20$
$= \underline{\underline{136{\cdot}8\ \text{N}}}$

(ii) $a = \dfrac{F}{M} = \dfrac{(136{\cdot}8 - 20{\cdot}0)}{\left(\dfrac{400}{9{\cdot}8}\right)}$

$= \dfrac{116{\cdot}8}{40{\cdot}82}$

$= \underline{\underline{2{\cdot}86\ \text{ms}^{-2}}}$

(b) No effect.
The initial acceleration depends only upon
(i) Angle of slope.
(ii) Force of friction.

(c) As the speed of the sledge increases the frictional forces acting on it increases. It will eventually reach a TERMINAL VELOCITY when the forces acting on it are BALANCED. In this case the component of gravity is balanced by friction and air resistance.

QUESTION 3

(a) (i) $m_1u_1 + m_2u_2 = (m_1 + m_2)V$
$(1200 \times 18) + (1000 \times -10{\cdot}8) = (2200)V$
$21\,600 - 10\,800 = 2200\,V$
$V = \dfrac{10\,800}{2200} = \underline{\underline{+4{\cdot}90\ \text{ms}^{-1}}}$

(ii) If E_k is not conserved it is inelastic.

BEFORE collision

$E_k = \left(\frac{1}{2} \times 1200 \times 18^2\right) + \left(\frac{1}{2} \times 1000 \times 10{\cdot}8^2\right)$
$= 194\,400 + 58\,320$
$= 252\,720\ \text{J}$

AFTER collision

$E_k = \frac{1}{2} \times 2200 \times (4{\cdot}9)^2$
$= 26\,411\ \text{J}$

Therefore kinetic energy is lost. Therefore collision is inelastic.

(b) (i) $\bar{F} = \frac{m(v-u)}{t}$

$\bar{F} = \frac{5(0-20)}{0 \cdot 02}$

$= \frac{-100}{0 \cdot 02}$

$= \underline{\underline{-5000 \text{ N}}}$

(ii) $P = \frac{F}{A}$

$= \frac{5000}{5 \times 10^{-4}}$

$= \underline{\underline{1 \times 10^7 \text{ Pa}}}$

(iii) The airbag increases the time for head to decelerate hence decreasing the average force.
Also the head is in contact with a much larger area, decreasing the pressure on the skull.

QUESTION 4

(a)

P(k Pa)	100	150	200	250
Vol cm^3	14·7	9·9	7·4	5·9
$P \times V$	1470	1485	1480	1475

Average $P \times V = 1478$

$P \times V = \underline{\underline{\text{constant (approx.)}}}$

(b) Assuming constant = 1478
then $P \times V = 1478$
$P \times 5 = 1478$

$P = \frac{1478}{5} = \underline{\underline{295 \cdot 6 \text{ k Pa}}}$

(c) The piston will be forced back up the syringe. When compressed, the air molecules in the syringe hit the inside of the piston MORE OFTEN than particles hit the outside and will force it upwards until the pressure inside equals the pressure outside.

(d) The results would be less accurate. The volume of trapped air would be greater than that shown on the syringe. $P \times V$ values would not be constant.

QUESTION 5

(a) (i) 0 V

(ii) $\frac{6 \cdot 6}{3 \cdot 3} = \frac{1}{R}$

$\therefore 2 = \frac{1}{R}$

$\therefore R = \underline{\underline{0 \cdot 5 \text{ k}\Omega}}$

(b) (i) 420 Ω

(ii) $\frac{1000}{1420} \times 9 \text{ V}$

$= \underline{\underline{6 \cdot 34 \text{ V}}}$

(iii) Voltage across 6·6 k = 6·0 V
Meter will read $6 \cdot 34 - 6 \cdot 0 = \underline{\underline{0 \cdot 34 \text{ V}}}$

QUESTION 6

(a) $W = QV$

$= 1 \cdot 6 \times 10^{-19} \times 25 \times 10^3$

$= 40 \times 10^{-16}$

$= \underline{\underline{4 \times 10^{-15} \text{ J}}}$

(b) KE at B $= 1 \cdot 3 \times 10^{-16} + 4 \times 10^{-15}$

$= 41 \cdot 3 \times 10^{-16}$

$\frac{1}{2} mv^2 = 41 \cdot 3 \times 10^{-16}$

$v^2 = \frac{2 \times 41 \cdot 3 \times 10^{-6}}{1 \cdot 673 \times 10^{-27}}$

$v^2 = 4 \cdot 94 \times 10^{12}$

$v = \underline{\underline{2 \cdot 22 \times 10^6 \text{ m s}^{-1}}}$

(c) $Fd = QV$

$\therefore F = \frac{QV}{d}$

$= \frac{1{\cdot}6 \times 10^{-19} \times 25 \times 10^{3}}{1{\cdot}2}$

$= \underline{\underline{3{\cdot}33 \times 10^{-15}\text{ N}}}$

QUESTION 7

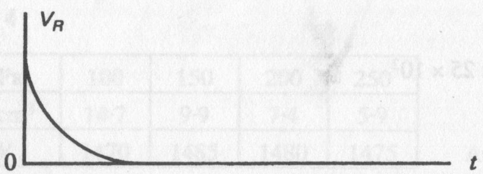
(a) (i) 6 V

(ii) $I_{MAX} = \frac{V}{R}$

$= \frac{6}{800}$

$= \underline{\underline{7{\cdot}5\text{ mA}}}$

(iii)



(b) The discharge curve is much steeper than the charging curve, and has a higher initial value, indicating that resistance must have been lower since

$\underline{\underline{I \propto \frac{1}{R}}}$

(c) $E = \frac{1}{2}CV^2$

$= \frac{1}{2} \times 10\,000 \times 10^{-6} \times 6^2$

$= \underline{\underline{0{\cdot}18\text{ J}}}$

QUESTION 8

(a) (i) Differential mode

(ii) $V_0 = \frac{R_f}{R_1}(V_2 - V_1)$

$V_0 = \frac{10 \times 10^3}{2 \times 10^3}(0{\cdot}4 - 0{\cdot}3)$

$V_0 = 5(0{\cdot}1)$

$V_0 = \underline{\underline{0{\cdot}5\text{ V}}}$

(b) (i) This amplifier is in inverting mode.

$V_0 = \frac{R_f}{R_1}(-V_1)$

$-4{\cdot}0 = \frac{R_f}{2 \times 10^3}(-0{\cdot}5)$

$\left(\frac{-4{\cdot}0}{-0{\cdot}5}\right) \times 2 \times 10^3 = R_f$

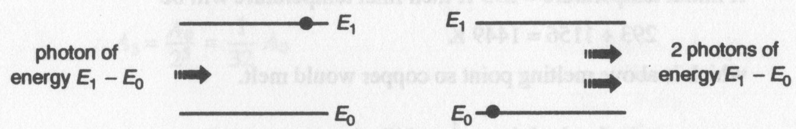
$8 \times 2 \times 10^3 = R_f$

$R_f = \underline{\underline{16\text{ k}\Omega}}$

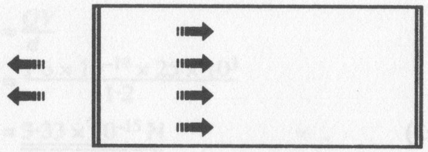
(ii) As R is increased feedback is decreased resulting in increased gain therefore V_0 increases until eventual saturation.

QUESTION 9

(a) "Simulated emission" occurs when electrons are deliberately encouraged to fall from higher to lower energy levels and emit a photon of energy. This can be achieved by sending another photon of the same energy towards the electron and stimulating it to fall.



The laser uses stimulated emission to produce a narrow parallel beam of coherent, monochromatic light.



It consists of a tube with a mirror at each end, one of which is only partially reflecting. Once the lasing process begins, photons will bounce back and forth along the tube, stimulating more photon emission as they go. Some photons exit from the semi-silvered mirror as the laser beam.

(b) (i) $P = I \times A$

$\therefore P = 4 \times 10^5 \times 1{\cdot}25 \times 10^{-5}$

$= \underline{\underline{5\ \text{W}}}$

In 100 seconds

$E = P \times t$

$= 5 \times 100$

$= \underline{\underline{500\ \text{J}}}$ are delivered

(ii) For copper

Melting point = 1357 K

Specific heat capacity = $3{\cdot}86 \times 10^2$ J kg^{-1} K^{-1}

With the addition of 500 J of energy, the rise in temperature will be

$$\Delta T = \frac{E}{cm} = \frac{500}{3{\cdot}86 \times 10^2 \times 1{\cdot}12 \times 10^{-3}}$$

$= 1156$ K

If initial temperature = 293 K then final temperature will be

$293 + 1156 = 1449$ K

which is above melting point so copper would melt.

QUESTION 10

(a) Dose equivalent = Absorbed Dose Rate × Quality Factor

i.e. $\dot{H} = \dot{D} \times Q$

For γ $\dot{H} = 100 \times 10^{-6} \times 1 = 100 \times 10^{-6}$ Sv h^{-1}

Fast neutrons $\dot{H} = 400 \times 10^{-6} \times 10 = 4000 \times 10^{-6}$ Sv h^{-1}

For α $\dot{H} = 50 \times 10^{-6} \times 20 = 1000 \times 10^{-6}$ Sv h^{-1}

The most harmful is likely to be fast neutrons.

(b) (i) For fast neutrons $\dot{H} = 4$ mSv h^{-1}

To receive 5 mSv requires $\frac{5}{4} \times 1$ hour = $\underline{\underline{\text{1 hour 15 minutes}}}$

(ii) 1 gray = 1 joule per kg

$D = \frac{E}{m}$

For fast neutrons, $\dot{D} = 400 \times 10^{-6}$ Gy h^{-1}

So in 2 hours, $D = 800$ μGy

$\therefore \quad 800 \times 10^{-6} = \frac{E}{25 \times 10^{-3}}$

$\therefore \quad E = 800 \times 10^{-6} \times 25 \times 10^{-3}$

$= \underline{\underline{20 \times 10^{-6}\ \text{J}}}$

(c) (i) The half value thickness is the amount of a material which will decrease the effect of radiation by half.

(ii) 3·5 cm = 5 × 7 mm = 5 × half thickness

For any material

$$A_n = \frac{A_0}{2^n}$$

A_0 → original count rate

A_n → Count rate after 'n' half thicknesses

n → n = number of half value thicknesses

$\therefore A_5 = \frac{A_0}{2^5} = \frac{1}{32} A_0$

Thus the radiation received will be $\frac{1}{32}$ × original radiation.

HIGHER PHYSICS ANSWERS — 1996

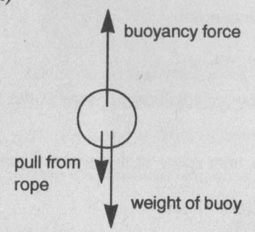
Paper I — Section A

1. C	2. C	3. B	4. D	5. B
6. B	7. E	8. C	9. C	10. C
11. E	12. D	13. A	14. D	15. D
16. C	17. A	18. E	19. E	20. C
21. C	22. E	23. A	24. B	25. E
26. A	27. A	28. B	29. B	30. E

Section B

31. Flight time = 0·3 s
Distance arrow falls in this time $= \frac{1}{2} g t^2$
$= 0{\cdot}44$
Thus distance < 0·6 m so arrow hits target.

32. *(a)* (i)



(ii) 1250 N (b) 1250 N

33. Brightness decreases. Larger current reduces the terminal p.d. Voltage across lamp is reduced. Power of lamp is reduced.

34. *(a)* 8·48 V *(b)* 17·9 W

35. 8·6°

36. *(a)* 6 *(b)* E_3 to E_2 *(c)* More electrons make these transitions in a given time.

37. $7{\cdot}8 \times 10^{-20}$ J

QUESTION 11

(a) **(i) Neutron induced nuclear fission.**

(ii) Statement A masses $\times 10^{-25}$ kg

LHS	RHS
3·091	2·221
0·017	1·626
	0·068
3·918	3·915

Difference = 0·003 × 10^{-25} kg

Statement B masses $\times 10^{-25}$ kg

LHS	RHS
3·091	2·388
0·017	1·492
	0·034
3·918	3·914

Difference = 0·004 × 10^{-25} kg

(iii) Reaction B will release greater amounts of energy as $E = mc^2$ and E is proportional to mass loss, m.

(b) **(i) 92 = Atomic number stating there are 92 protons in nucleus.**

235 = Mass number. This is total number of neutrons plus protons in the nucleus. By subtraction there must be 143 neutrons.

(ii) To determine y use principle of charge conservation and atomic numbers.

LHS	RHS
92	42
0	y
	0
	−4

If LHS = RHS then

$$92 = 42 + y - 4$$
$$y = 92 - 38$$
$$= \underline{\underline{54}}$$