Section A

1. **D**	11. **D**
2. **E**	12. **E**
3. **A**	13. **C**
4. **D**	14. **B**
5. **A**	15. **B**
6. **C**	16. **B**
7. **E**	17. **D**
8. **C**	18. **A**
9. **B**	19. **E**
10. **E**	20. **A**

Section B

21.a.i. $V_{horizontal}=V_{resultant} \times \cos\theta$

$V=35\times\cos40^{\circ}$

$\mathbf{V_{hor} = 26.81(m/s)}$

a.ii. $V_{vertical}=V_{resultant} \times \sin\theta$

$V_{ver}=35\times\sin40^{\circ}$

$\mathbf{V_{ver} = 22.5(m/s)}$

a.iii. Maximum height reached when the vertical component of velocity (V_{ver}) is 0m/s.
The vertical component of velocity calculated in part a.ii. is the initial velocity (u) for the purpose of this calculation.

$v_{ver} = 0(m/s)$
$u_{ver} = 22.5(m/s)$
$a = -9.8(m/s/s)$
$t = ?$

$v = u + at$
$t = (v-u)/a$
$t = (0-22.5)/-9.8$
$\mathbf{t = 2.29(s)}$

b. Horizontal distance is calculated by multiplying the total time of flight by the horizontal velocity, which is constant throughout the flight.

Total time = $[(2\times2.29) + 0.48]$s
$t_{total} = 5.06(s)$
$V_{hor}=26.81(m/s)$

$d = V_{hor} \times t_{total}$
$d = 26.81(m/s)\times5.06(s)$
$\mathbf{d = 135.66(m)}$

22.a. $\Delta P_s = m_s(v_s-u_s)$

$\Delta P_s = 38(4.6-2.2)$

$\Delta P_s = 91.2(kgm/s)$

b. $F_{avg}t_c = \Delta P$

$t_c = \Delta P/F_{avg}$

$t_c = 91.2/130$

$\mathbf{t_c = 0.7(s)}$

c. $\Delta P_R = -\Delta P_S$

$\Delta P_R = -91.2(kgm/s)$

$\Delta P_R = m_R(v_R-u_R)$

$-91.2 = 54(v_R-2.2)$

$\mathbf{v_R = 0.51(m/s)}$

d. If kinetic energy is conserved the interaction is elastic.

$Ek_{before} = 1/2M_RU_R^2 + 1/2M_SU_S^2$

$Ek_{before} = 0.5x54x2.2^2 + 0.5x38X2.2^2$

$Ek_{before} = 222.64(J)$

$Ek_{after} = 1/2M_RV_R^2 + 1/2M_SV_S^2$

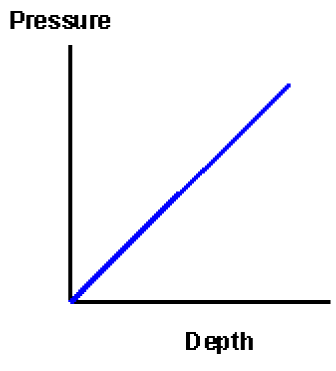
$Ek_{after} = 0.5x54x0.51^2 + 0.5x38x4.6^2$

$Ek_{after} = 409(J)$

The gain in kinetic energy indicates that the collision is **NOT ELASTIC.**

The interaction is more like an explosion.

23.a.i.



a.ii. $P_{liquid} = \rho gh$

$P_{liquid} = 1000x9.8x0.25$

$\mathbf{P_{liquid} = 2450(Pa)}$

a.iii. As the depth increases the total pressure acting on the air inside the tubing increases. Liquid enters the tube, compressing the air, until the total pressure acting on the air inside the tube is equal to the pressure of the air inside the tube.

b. The pressure resulting from tank and water can be calculated using:

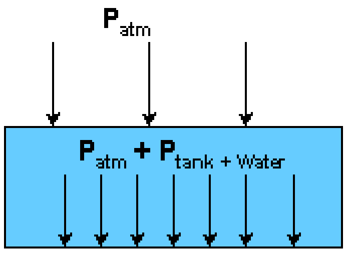
$P = F/A$ where F is the weight of the tank and water.

$F = w_{total} = m_{total}g$
$w_{total} = (2.7x10^3+300)9.8$
$w_{total} = 3000x9.8$
$w_{total} = 29400(N)$

$A = 2.0x1.5 = 3.0m^2$

$P = 29400/3$
$P = 9800(Pa)$

Atmospheric pressure is pushing down on the tank. This means that the total pressure acting on the surface that the tank is resting on is the sum of the atmospheric pressure and the pressure resulting from the weight of the tank.



$P_{total} = P_{tank+water} + P_{atmospheric}$
$P_{total} = 9800 + 1.01x10^5$
$\mathbf{P_{total} = 1.108x10^5(Pa)}$

24.a. $P_1 = 1.56x10^5Pa$
$T_1 = (27+273)K = 300k$

$P_2 = ?$
$T_2 = (77+273)K = 350k$

$P_1/T_1 = P_2/T_2$
$P_2 = P_1T_2/T_1$
$P_2 = 1.56x10^5x350/300$
$\mathbf{P_2 = 1.82x10^5Pa}$

b.i. $P = I^2R_{element}$

$I = V/R_{total}$

$I = 30/(0.5+1.5) = 30/2$
$I = 15A$

$P = 15^2x0.5$
$\mathbf{P = 112.5W}$

b.ii. The output power of the element would be **less**.
This is because the current in the circuit would be less because of the increase of the total series

resistance of the circuit.

Other explanations involving V_{tpd} are also valid.

25.a.i. **Y-gain = 5volts/div**

a.ii. $f = 1/T$

$T = 2.5ms = 2.5x10^{-3}$
$f = 1/2.5x10^{-3}$
$f = 400Hz$

b.i. $V_{RMS} = V_{Peak}/SQRT2$
$V_{RMS} = 12/1.414$
$V_{RMS} = 8.49V$

b.ii. $E = 1/2(CV_{pk}^2)$
$E = 1/2(220x10^{-6}x12^2)$
$E = 0.016J$

b.iii. The reading on the ammeter increases because the current is directly proportional to the frequency.

b.iv. The capacitor is constantly charging and discharging, as the polarity of the supply voltage changes in this ac circuit. The flow of charge during this process means that the current in the circuit does not fall to zero. In a dc circuit the capacitor charges and opposes the flow of charge from the supply. When fully charged no current flows in the circuit.

26.a. When the bridge is balanced:
$R_1/R_2 = R_3/R_4$

Where $R_1 = 5500\Omega$
$R_2 = R_{LDR}$
$R_3 = 330000\Omega$
$R_4 = 150000\Omega$

$R_{LDR} = (R_1xR_4)/R_3$
$R_{LDR} = (5500x150000)/330000)$
$R_{LDR} = 2500\Omega$

b.i. **MOSFET (n-channel)**

b.ii. $V_1 = V_X = 1.28V$
$V_2 = V_Y = 1.50V$

$V_{ouput} = (R_{feedback}/R_1)x(V_2-V_1)$
$V_{ouput} = (22.5/1.5)x(1.5-1.28)$
$V_{ouput} = 15x0.22$
$V_{ouput} = 3.3V$

b.iii. When water reaches the maximum level the beam of light is not totally internally reflected. This means that the light intensity incident on the LDR decreases, increasing its resistance and increasing V_X.
This decreases the output voltage from the differential

amplifier. When the output voltage falls below 2.0V the MOSFET does not conduct and the current in the solenoid falls to zero, closing the valve.

26.c. The incident angle at the glass water boundary is less than the critical angle so there is no total internal reflection.

27.a.i. The energy of the emitted photon is equal to the energy difference between levels.The longest wavelength radiation will have the lowest frequency and energy.

The smallest energy gap is beween E_4 and E_3

a.ii. $E_{photon} = E_3 - E_2$
$E_{photon} = (-2.4x10^{-19})-(-5.6x10^{-19})$
$E_{photon} = 3.2x10^{-19}J$

$E_{photon} = hf$
$f = E_{photon}/h$
$f = 3.2x10^{-19}/6.63x10^{-34}$
$\mathbf{f = 4.83x10^{14}Hz}$

b.i. $f_{air} = f_{glass}$
$\mathbf{f_{glass} = 4.74x10^{14}Hz}$

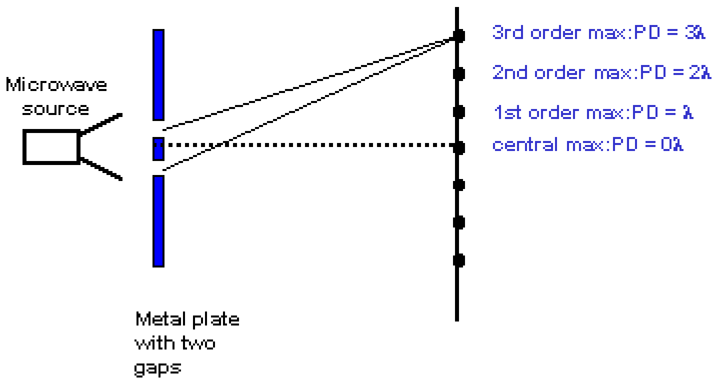
b.ii. $v_{air} = f_{air}\lambda_{air}$
$\lambda_{air} = v_{air}/f_{air}$
$\lambda_{air} = 3x10^8/4.74x10^{14}$
$\lambda_{air} = 632.9nm$

$\lambda_{glass} = \lambda_{air}/n$
$\lambda_{glass} = 632.9/1.6$
$\boldsymbol{\lambda_{glass} = 395.6nm}$

28.a.i. Maxima are produced when the path difference of the microwaves, from each gap, to a point along AB is zero or a whole number of wavelengths. This is because constructive interference occurs at these points as the waves are in phase.

Minima are produced when the path difference of the microwaves, from each gap, to a point along AB is $\lambda/2$, $3\lambda/2$, $5\lambda/2$, $7\lambda/2$ etc. This is because destructive interference occurs at these points as the waves are Π out of phase.

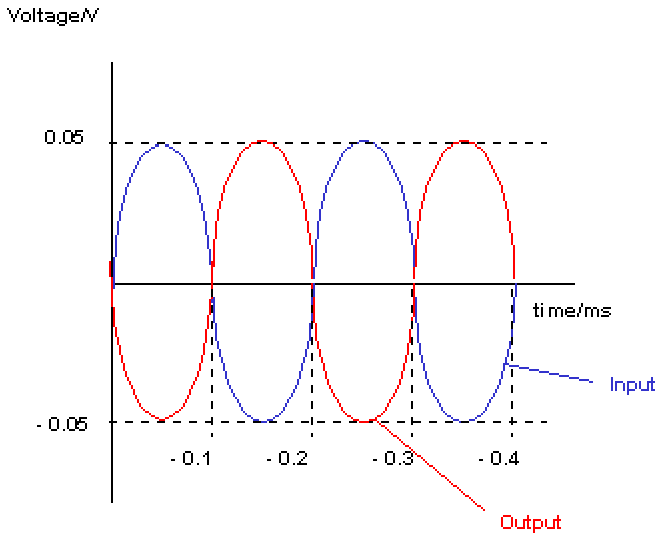
a.ii.



PD = (766 - 682)mm
PD = 84mm

Third Max PD = 3λ
3λ = 84mm
λ = 84/3
λ = 28mm

b.i. Gain = $-R_{feedback}/R_{input}$
Gain = -10kΩ/10kΩ
Gain = -1



$V_{output}/V_{input} = -R_{feedback}/R_{input}$
$V_{output} = -V_{input} x (R_{feedback}/R_{input})$
V_{output}(peak) = $-6x(3.0x10^3/2.0x10^3)$
V_{output}(peak) = -9V

b.ii.

29.a.i. $^{4}_{2}He$ is is an alpha particle.

a.ii. A = N/t

$N = 7.2x10^5$ disintegrations
$t = 2$ minutes $= 120s$

$A = 7.2x10^5/120$
$A = 6000Bq = 6kBq$

b.i. Half value thickness($t_{1/2}$) = thickness of barrier required to reduce the count rate by half.

60counts/s -> 30counts/s requires 3cm
30counts/s -> 15counts/s requires 3cm

$t_{1/2} = 3cm$

b.ii. The bar indicates the uncertainty in the average reading. This results from the random nature of radioactive decay.

c.i. $H_{total} = 6.4x10^{-5}Sv$

Alpha
$Q_\alpha = 20$
$H_\alpha = Q_\alpha x D_\alpha$
$H_\alpha = 20D_\alpha$

Gamma
$Q_\gamma = 1$
$D_\gamma = 1.2x10^{-5}Gy$
$H_\gamma = QxD_\gamma$
$H_\gamma = 1x1.2x10^{-5}Sv$
$H_\gamma = 1.2x10^{-5}Sv$

$H_{total} = H_\alpha + H_\gamma$
$6.4x10^{-5}Sv = H_\alpha + 1.2x10^{-5}Sv$
$H_\alpha = 6.4x10^{-5}Sv - 1.2x10^{-5}Sv$
$H_\alpha = 5.2x10^{-5}Sv$

$H_\alpha = QD_\alpha$
$H_\alpha = 20D_\alpha$
$20D_\alpha = 5.2x10^{-5}Sv$
$D_\alpha = 5.2x10^{-5}/20$

$D_\alpha = 2.6x10^{-6}Gy = 2.6\mu Gy$