Section A

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

Section B

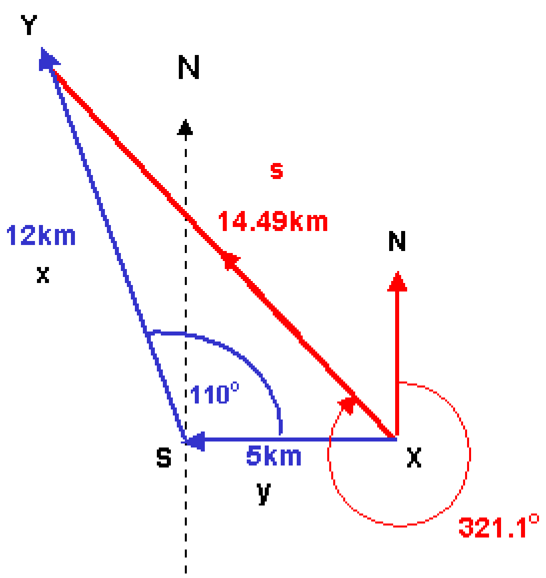
21.a. Speed is a scalar with magnitude only.
Velocity is a vector with magnitude and velocity.

b.i. Distance(1) = Speed x time
10.0km/h x 0.5h
5km

Distance(2) = 8.0km/h x 1.5
12km

Distance(Total) = Distance(1)+Distance(2)
Distance(Total) = 5km + 12km
Distance(Total) = 17km

b.ii. Draw an accurate scale diagram and take careful measurements



or use trigonometry.

Use the cosine rule to calculate the resultant displacement.

$s^2=x^2 + y^2 -2xycosX$
$s^2=12^2 + 5^2 -2x12x5cos110^o$
$s^2=169 + 41.04$
s = SQRT(210.4)
s =14.49km

Use the sine rule to calculate angle X and hence the bearing.

s/sinS = x/sinX
sinX = (xsinS)/s
sinX = $(12sin110^o)/14.49$
sinX = (11.28)/14.49
sinX = 0.778

X = 51.1^o

bearing 321.1^o

b.iii.velocity = displacement/time

s = 14.49km v = 14.49/2
t = 2 h **v = 7.24km/h**

c. Time for Leeuvin to sail directly:

t = s/v
t = 14.49/7.5
t = 1.932h = 1hour 55.9minutes

Time for Leeuvin to reach Y after the Mir passes X
1h 55.9min + 15min = 2h 10.9min

This is longer than the 2h journey of the Mir.

Leeuvin reaches Y 10.9 minutes after Mir.

22.a.i.u = 60m/s $v^2 = u^2 + 2as$
v = 0m/s $s = (v^2 - u^2)/2a$
t = 40s
s = ? a = (v-u)/t
a = (0 - 60)/40 = -1.5m/s/s

$s = (0^2 - 60^2)/2x-1.5$
s = -3600/-3
s = 1200m

a.ii.F_{avg} = m(v-u)/t

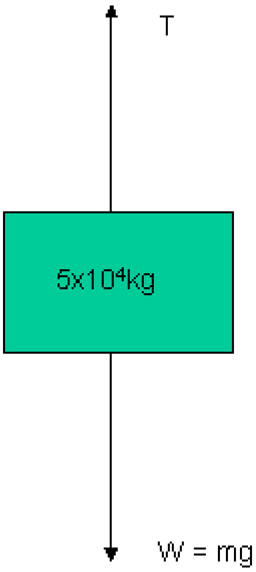
m = $7.5x10^5$kg $F_{avg} = 7.5x10^5(0-60)/40$
u = 60m/s **F_{avg} = -11.25x10^5N**
v = 0m/s The force acts in the opposite direction
t = 40s to the motion.

Kinetic energy equated to the work done by the braking force also produces the above answer.

b. $I_{rms} = 2.5x10^3A$
$P = 8.5x10^6(J/s)$ or (W)

$P_{rms} = I_{rms} \times V_{rms}$
$V_{rms} = P_{rms}/I_{rms}$
$V_{rms} = 8.5x10^6/2.5x10^3$
$\mathbf{V_{rms} = 3400V}$

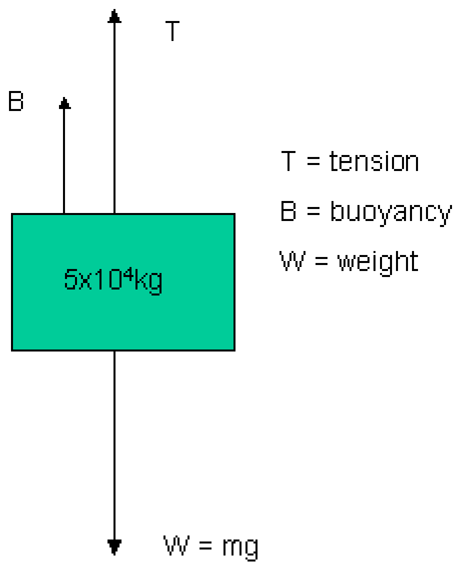
23.a. As the manifold is stationary the upward forces balance the downward forces. Tension = Weight



$w = mg$
$w = 5.0x10^4kg \times 9.8N/kg$
$w = 490000N$

T = 490000N (upwards)

b.i.



b.ii. Again as the manifold is stationary the upward forces balance the downward forces.

$T + B = W$
$2.5x10^5 + B = 490000N$
$B = 490000 - 250000$
$B = 240000N$

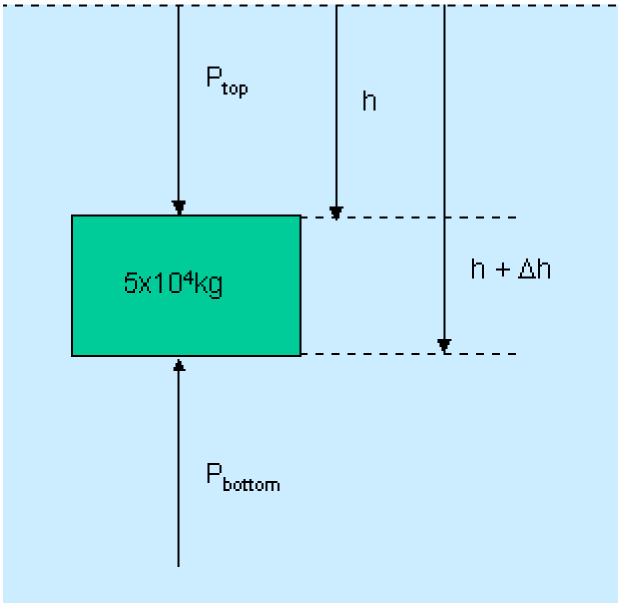
The buoyancy force is a result of the pressure difference between the upper and lower surfaces.

$B = (P_{lower} - P_{upper})A$
$\Delta P = B/A$
$\Delta P = 240000N/8.0m^2$
$\Delta P = 30000Pa$ As required

c. There is no change in the pressure difference.

$P_{liquid}(top) = \rho gh$
$P_{liquid}(bottom) = \rho g(h+\Delta h)$

$\Delta P = P_{liquid}(bottom) - P_{liquid}(top)$
$\Delta P = \rho g\Delta h$



Only the difference in the depth(Δh) of the top and bottom surfaces affects the pressure difference.

24.a.i. r = 2.0Ω

emf = 9.0V (open circuit voltage)
V_{tpd} = 7.8V

V_{lost} = emf - V_{tpd}
V_{lost} = 9.0 - 7.8
V_{lost} = 1.2V

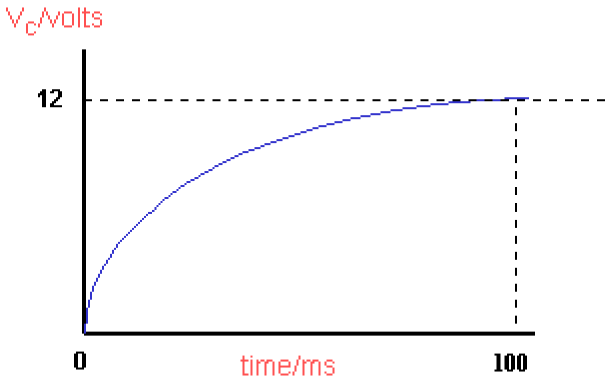
V_{lost} = Ir
I = V_{lost}/r
I = 1.2/2.0
I = 0.6A

V_{tpd} = V_R
V_R = IR
R = V_R/I
R = 7.8/0.6
R = 13Ω

24.a.ii. When S_1 is closed there is a current through the internal resistor. The voltage drop across this resistor is "lost" and produces the decreased reading on the voltmeter.

b. The 30Ω resistor in parallel with the original load resistor decreases the effective resistance of the load. More current therefore flows through the internal resistor resulting in more "lost volts". This means the **voltmeter reading decreases**.

25.a.



When fully charged the current in the circuit falls to zero and the voltage across the capacitor is equal to the supply voltage.

25.bi. $I = 20mA$
$R = 400\Omega$
$V_R = IR$

$V_R = 20\times10^{-3}\times400$
$V_R = 8V$

$V_{supply} = V_R + V_C$
$V_C = V_{supply} - V_R$
$V_C = 12 - 8$
$\mathbf{V_C = 4V}$

b.ii. $E = 1/2(CV^2)$
$E = 0.5 \times 100\times10^{-6} \times 4^2$
$E = 0.0008J$ ($800\mu J$)

c. Reduce the value of the resistor in the circuit to less than 400Ω.

d. The charging time is less. This means the capacitor must have a value **less than 400μF**

26.a. Differential op-amp
$V_{out} = (R_f/R_1)(V_2-V_1)$
$V_{out} = (120/10)(7.52-7.50)$
$V_{out} = 12 \times 0.02$
$\mathbf{V_{out} = 0.24V}$

b. As the temperature increases the:

Resistance of the thermistor decreases increasing V_2 and V_{out}.
When V_{out} increases to 0.7V or above the transistor conducts.
The electromagnet in the relay gets magnitised and closes the switch to the alarm.

c. $V_{out} = (R_f/R_1)(V_2-V_1)$
$0.72 = 12(V_2 - 7.50)$
$V_2 = (0.72/12) + 7.50$

$V_2 = 0.06 + 7.50$
$V_2 = 7.56V$

This corresponds to a **temperature of 36°C**

27.a.i. Angle air = 82°
Angle liquid = 45°

$n_{liquid(red)} = \sin(air)/\sin(liquid)$
$n_{liqiud(red)} = \sin 82°/\sin 45°$
$n_{liquid(red)} = 0.990/0.707$
$\mathbf{n_{liquid(red)} = 1.40}$

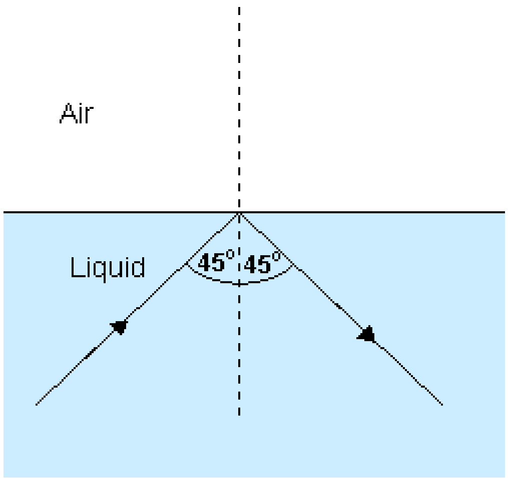
a.ii. The angle of refraction for blue light is **greater**.

$\sin\theta_{air} = n\sin\theta_{liquid}$
$\theta_{air} = \sin^{-1}(n\sin\theta_{liquid})$
As $n_{liquid(blue)} > {}_{liquid(red)}$ θ_{air} must be greater.

Note: θ_{air} is the angle of refraction.

b. $\theta_{critical} = \sin^{-1}(1/n)$
$\theta_{critical} = \sin^{-1}(1/1.44)$
$\theta_{critical} = \sin^{-1}(0.694)$
$\theta_{critical} = 43.9°$

This means that light incident at 45° will be totally internally reflected.



28.a.i. A passing photon can encourage or stimulate an electron to fall from a higher energy level in an atom to a lower one. This will happen if the passing photon has the same energy as the energy gap between the two energy levels in the atom.

a.ii. Amplification is produced because each photon produced by stimulated emission becomes a new stimulating photon. One becomes two, two becomes four, four becomes eight and so on.

b. Grating Equation : $d\sin\theta = n\lambda$

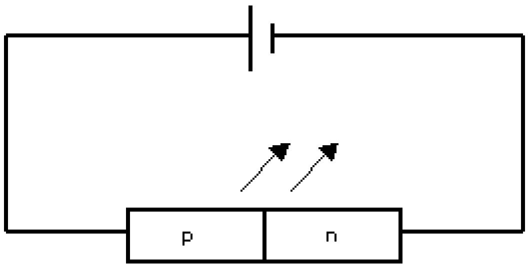
$d = ?m$
$n = 1$
$\theta = 37/2^\circ = 18.5^\circ$
$\lambda = 633nm = 633 \times 10^{-9}m$

$d = n\lambda/\sin\theta$
$d = 1 \times 633 \times 10^{-9}/\sin 18.5^\circ$
$d = 1.995 \times 10^{-6}m$

Lines per metre = 1/d
Lines per metre = $1/1.995 \times 10^{-6}$
Lines per metre = 501271

c. The **wavelength has been decreased.** Shorter wavelengths are diffracted less than longer ones so the maxima are closer together.

29.a.



Forward biased p-n junction

b. In forward bias the junction conducts if the applied voltage is high enough. Higher energy electrons flowing from the n-type material fall into holes, at a lower energy level, in the p-type material. The electrons give up energy in the form of photons as they do this.

c.i. $E = 3.68 \times 10^{-19}J$
$h = 6.63 \times 10^{-34}Js$
$f = ?$

$E = hf$
$f = E/h$
$f = 3.68 \times 10^{-19}/6.63 \times 10^{-34}$
$f = 5.55 \times 10^{14}Hz$

$\lambda = v/f$
$\lambda = 3 \times 10^{8}/5.55 \times 10^{14}$
$\boldsymbol{\lambda = 540nm}$

ii. $E = 3.68 \times 10^{-19}J$
$q = 1.60 \times 10^{-19}C$
$V =$

$E = qV$
$V = E/q$
$V = 3.68 \times 10^{-19}/1.60 \times 10^{-19}$
V = 2.3V

30.a.i. 92 is the atomic number. The number of protons in the uranium nucleus.

a.ii. 235 is the mass number. The number of protons plus neutrons in the uranium nucleus.

b. The two neutrons produced in the fission reaction can be absorbed by two other uranium nuclei and produce two more fissions.

c. Total mass before = $(390.173 + 1.675)\text{x}10^{-27}$
$= 391.848\text{x}10^{-27}\text{kg}$

Total mass after = $(232.242 + 155.884 + 2\text{x}1.675)\text{x}10^{-27}$
$391.476\text{x}10^{-27}\text{kg}$

Mass defect(Δm) = $(391.848 - 391.476)\text{x}10^{-27}$
$= 0.372\text{x}10^{-27}\text{kg}$

$E = \Delta mc^2$
$E = 0.372\text{x}10^{-27} \text{ x } (3\text{x}10^8)^2$
$\mathbf{E = 33.48\text{x}10^{-12}J}$