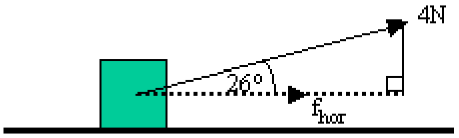
## Section A

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

## Section B

21.a.i.




$F_{hor} = F_{Resultant}\cos\theta$
$F_{hor} = 4\cos 26°$
$F_{hor} = 3.6N$

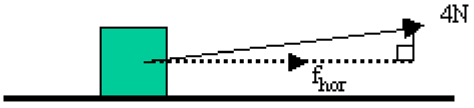
a.ii. $F_{hor} = F_{un} = 3.6N$
m = 18kg
a = ?

$a = F_{un}/m$
$a = 3.6/18$
**$a = 0.2 m/s^2$**

a.iii. u = 0m/s
$a = 0.2m/s^2$
t = 7s
s = ?

$s = ut + 1/2at^2$
$s = 0x7 + 0.5x0.2x7^2$
**s = 4.9m**

b.




By decreasing the angle the cosine of the angle will increase.
This makes the horizontal force greater as : $F_{hor} = F_{Resultant}\cos\theta$
The accelerating force, and the consequent acceleration, is therefore greater.
Substituting a greater acceleration into the equation used in part a.iii. will result in a greater distance being calculated.

22.a.i.

| Experiment Number | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|

| | | | | | | |
|---|---|---|---|---|---|---|
| Mass of flask and air/kg | 0.8750 | 0.8762 | 0.8748 | 0.8755 | 0.8760 | 0.8757 |
| Mass of evacuated mask/kg | 0.8722 | 0.8736 | 0.8721 | 0.8728 | 0.8738 | 0.8732 |
| Mass of air removed/kg | 0.0028 | 0.0026 | 0.0027 | 0.0027 | 0.0022 | 0.0025 |

a.ii. Mean = Total/Number of readings
Mean = (0.0028+0.0026+0.0027+0.0027+0.0022+0.0025)/6
Mean = (0.0155/6)
**Mean = 0.00258kg**

Random uncertainty = (max - min)/N
Random uncertainty = (0.0028 - 0.0022)/6
**Random uncertainty = 0.0001kg**

Mass of air = (0.0026+-0.0001)kg

a.iii. mass(mean) = 0.0026kg
volume = $2.0\times10^{-3}m^3$

density = mass/volume
$\rho = m/V$
$\rho = 0.00258/2.0\times10^{-3}$
**$\rho = 1.29kg/m^3$**

a.iv. A flask of larger volume is better because this increases the mass and volume of air and used in the experiment. This should result in a smaller percentage error in the measurements of both mass and volume of the gas. This will in turn reduce the percentage error in the calculated density of air.

22.bi. Pressure and volume are the important variables.
This means Boyle's law requires to be used. However, as it is the length of the cylinder that is given and not the volume the fact that:
Volume(V) = Cylinder cross sectional area(A) x Length of the piston(L)
must be used in the solution.

$V_1 = L_1A$
$V_2 = L_2A$
$P_1 = 1x10^{-5}Pa$
$P_2 = ?$

$V_1/V_2 = P_1/P_2$
$V_1/V_2 = L_1A/L_2A = L_1/L_2$
$=> L_1/L_2 = P_1/P_2$
$P_2 = (L_2/L_1)P_1$
$P_2 = (360/160)x1x10^{-5}$
**$P_2 = 2.25x10^{-5}Pa$**

b.ii. The mass of the gas trapped is constant.

b.iii. Pressure is caused by the gas particles exerting a force on the walls of the container. When the volume of the container decreases there is an increase in the collision rate, meaning that more force is exerted on the container walls. This increases the pressure as pressure is a measure of force per unit area (P = F/A).

23.a.i.
(A) Contact time($t_c$) = $3.0x10^{-3}s$
$F_{avg} = F_{un} = 0.5N$

NB/ $F_{avg} = F_{un}$ because there are no unbalanced forces.

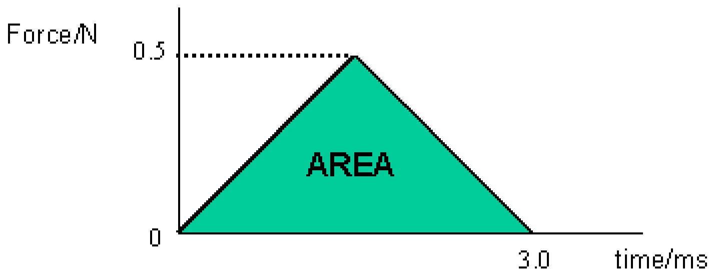
Impulse = $F_{avg} \times t_c$
Impulse = $0.5 \times 3.0\text{x}10^{-3}$
**Impulse = $1.5\text{x}10^{-3}$Ns (kgm/s)**

(B) Impulse = Change in Momentum
Impulse = mv-mu
Impulse = m(v-u)

u = 0m/s As the bead of water is initially at rest.
m = $2.5\text{x}10^{-5}$kg

=> v = Impulse/m
v = $1.5\text{x}10^{-3}/2.5\text{x}10^{-5}$
**v = 60m/s**

a.ii. The impulse can be calculated from the area under the force time graph.




A = 1/2bh (Area of a triangle formula)
A = $0.5 \times 3.0\text{x}10^{-3} \times 0.5$
A = 0.75

=> Actual impulse = $0.75\text{x}10^{-3}$Ns

v = Impulse/m (from above)
v = $0.75\text{x}10^{-3}/2.5\text{x}10^{-5}$
**v = 30m/s**

b. The bead gains kinetic energy as it is accelerated in the electric field between the plates. The gain in the kinetic energy of the bead, with charge q, accelerated by a potential difference V, can be calculated using:

$E_k$(gain) = qV

This is equal to the gain in kinetic energy:

$E_{k(gain)} = mv^2/2$

=>$mv^2/2$ = qV q = $6.5\text{x}10^{-6}$C
$v^2$ = 2qV/m V = $5\text{x}10^3$V
v = SQRT(2qV/m) m = $4.0\text{x}10^{-5}$kg

v = SQRT($2\text{x}6.5\text{x}10^{-6}\text{x}5\text{x}10^3$)/$4.0\text{x}10^{-5}$
v = SQRT(1625)
**v = 40.3m/s**

24.a.i. The emf can be found by projecting the graph line back until it cuts the voltage axis.

**emf = 4.8V**

a.ii. The internal resistance is equal to the negative of the gradient of the line given.

$m = (y_1-y_2)/(x_1-x_2)$
$m = (4.0-2.0)/(0.4-1.4)$
$m = 2.0/-1.0$
$m = -2$

**r = 2Ω**

To justify the above consider:

$y = mx + c$ ...1
$V = mI + c$ ...2
$V_{tpd} = E - Ir$ ...3
$V_{tpd} = -Ir + E$ ...4

From equation (3)
When I = 0A : $V_{tpd}$=emf

Comparing (2) and (4)
$m = -r$

24.b.i. emf = $V_{tpd}+V_{lost}$
emf = IR+Ir

The condition for a short circuit is: R=0Ω
=> emf = Ir
I = emf/r
I = 12/0.050
**I = 240A**

b.ii. When the lamp is connected: R=2.5Ω

I = emf/(R+r)
I = 12/(2.5+0.05)
I = 4.71A

$P = I^2R$
$P = (4.71)^2 2.5$
**P = 55.46W**

25.a.i. The initial charging current($I_{max}$) occurs when all of the supply voltage($V_{supply}$) is across the 1.5kΩ resistor(R).

$I_{max} = V_{supply}/R$
$I_{max} = 6/1500$
**$I_{max} = 4x10^{-3}A$**

a.ii. When fully charged the voltage across the supply voltage is equal to
the voltage across the capacitor.
$V_{supply}$ = **$V_c$ = 6V**

$E_{capacitor} = QV_c/2$
$Q = CV_c$

$=> E_{capacitor} = CV_c^2/2$
$E_{capacitor} = 470x10^{-6}x6^2/2$
$\mathbf{E_{capacitor} = 8.46x10^{-3}J}$

a.iii. Increasing the supply voltage would increase the energy storing capacity of the capacitor. This is because the final voltage, across the fully charged capacitor, would be higher.

25.b. $E_{total} = 6.35x10^{-3}J$

$f_{photon} = 5.80x10^{14}Hz$
$h = 6.63x10^{-34}Js$
$E_{photon} = ?$

$E_{photon} = hf_{photon}$
$E_{photon} = 6.63x10^{-34} \text{ x } 5.80x10^{14}$
$E_{photon} = 3.84x10^{-19}J$

$E_{total} = NE_{photon}$
$N = E_{total}/E_{photon}$
$N = 6.35x10^{-3}/3.84x10^{-19}$
$\mathbf{N = 1.65x10^{16}}$

26.a.i. The amplifier is acting in inverting mode.

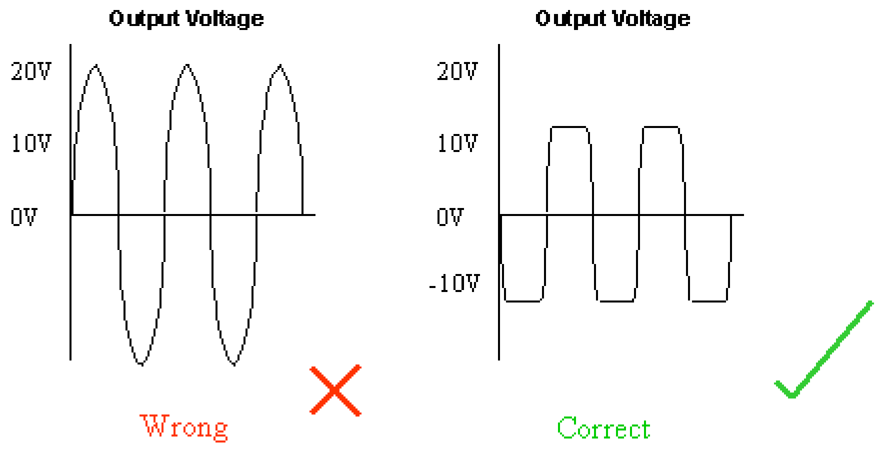
a.ii. The gain of the amplifier is calculated using the equation:

$V_{output}/V_{input} = -R_{feedback}/R_{input}$
$V_{output} = -V_{input}xR_{feedback}/R_{input}$
$V_{output} = -18^{-3}x1.6x10^6/20x10^3$

$\mathbf{V_{output} = -1.44V}$

a.iii. The output voltage is not affected. This is because the output voltage is still much lower than the supply voltage. Only when the calculated output voltage gets close to, or greater than, the supply voltage is the output voltage affected.

b.




1. Output not inverted.
2. No saturation

27.a. $d\sin\theta = n\lambda$

$d = 2.16\times10^{-6}$m
$n = 2$
$\lambda = 486\times10^{-9}$m
$\theta = ?$

$\sin\theta = n\lambda/d$
$\sin\theta = 2\times486\times10^{-9}/2.16\times10^{-6}$
$\sin\theta = 0.45$
$\boldsymbol{\theta = 26.74^\circ}$

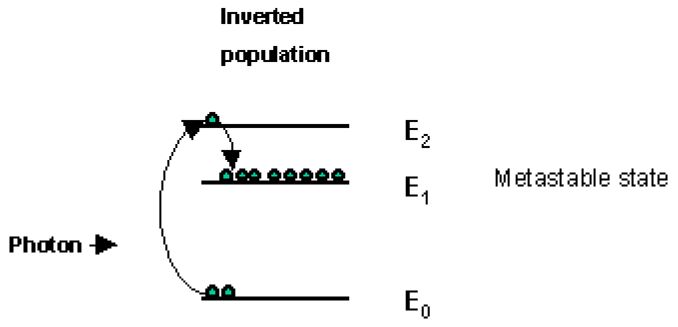
b.i. Angle i = $47^\circ$
Angle r = $27^\circ$

$n_{glass} = \sin(i)/\sin(r)$
$n_{glass} = \sin47^\circ/\sin27^\circ$
$n_{glass} = 0.731/0.454$
$\boldsymbol{n_{glass} = 1.61}$ ...as required

b.ii. $\theta_{critical} = \sin^{-1}(1/n)$
$\theta_{critical} = \sin^{-1}(1/1.61)$
$\theta_{critical} = \sin^{-1}(0.613)$
$\theta_{critical} = 38.4^\circ$

At point X the incident angle of $63^\circ$ is greater than the critical angle. This means that the light is totally internally reflected at this boundary.

28.a.




A high voltage or other energy source can be used to pump electrons up into higher energy states. For example, an electron can be pumped up to energy level ($E_2$) and then fall into the metastable state $E_1$, creating what is called an inverted population. A passing photon, having an energy equal to the energy gap $E_1$ to $E_0$ can encourage/stimulate an electron to drop from energy state $E_1$ to $E_0$ with the production of a photon in phase, with the same frequency and travelling parallel to the stimulating photon. Thereafter, photons produced by stimulated emission can cause further stimulated emission. This is the basis for stimulated emission and amplification.

b.i. $P = IA$

$I = 1020\text{Wm}^{-2}$

$A = \pi r^2$
$A = \pi x(5.00x10^{-4})^2$
$A = 7.85x10^{-7}m^{-2}$

$P = 1020x7.854x10^{-7}$
$\mathbf{P = 8.01x10^{-4}W}$

b.ii. The laser beam is non divergent. It does not spread out. This means the radius of the spot is a constant.

29.a.i. The reaction is **induced fission**. The reaction is described as this type because the Pu nuclei absorb neutrons and become unstable. The Pu nuclei then split and release energy.

a.ii. The energy released from the reaction is a result of the mass of the products being less than the mass of the reactants.

Mass of reactants = $3.9842x10^{-27}$kg
Mass of products = $3.9825x10^{-27}$kg

Mass defect = $(3.9842-3.9825)x10^{-27}$kg
**Mass defect = $0.0017x10^{-27}$kg**

This mass defect is converted into energy.

The energy is calculated using the equation: $E = mc^2$

$E = 0.0017 \times 10^{-27} \times (3 \times 10^{-27})^2$
**$E = 1.53 \times 10^{-13} J$**

b.i. $D = E/m$

$E = 9.6 \times 10^{-5} J$
$m = 0.5 kg$

$D = 9.6 \times 10^{-5}/0.5$
**$D = 1.92 \times 10^{-4} J/kg$ (Gy)**

b.ii. $H = QD$

$Q = 1$
$D = 1.92 \times 10^{-4} J/kg$

$H = 1 \times 1.92 \times 10^{-4}$
**$H = 1.92 \times 10^{-4} Sv$**

b.iii. Three half value thicknesses of lead (**120mm**) are required.