

# Candidate 1 evidence

Worksheet for question 3 (b)

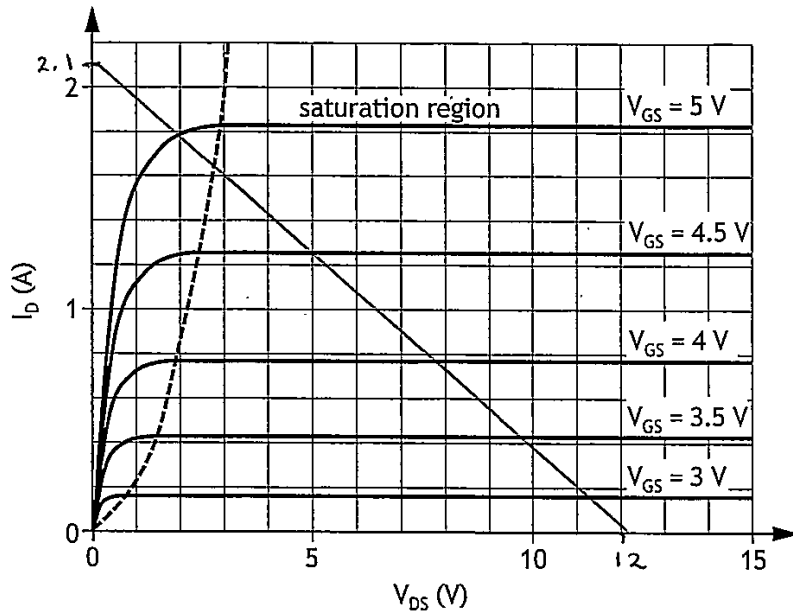
Stage	Precedents	Duration
A	----	4
B	----	1
C	B	4
D	A, B	7
E	C	3
F	E	6
G	A, C	7
H	D, F, G	3

(i)

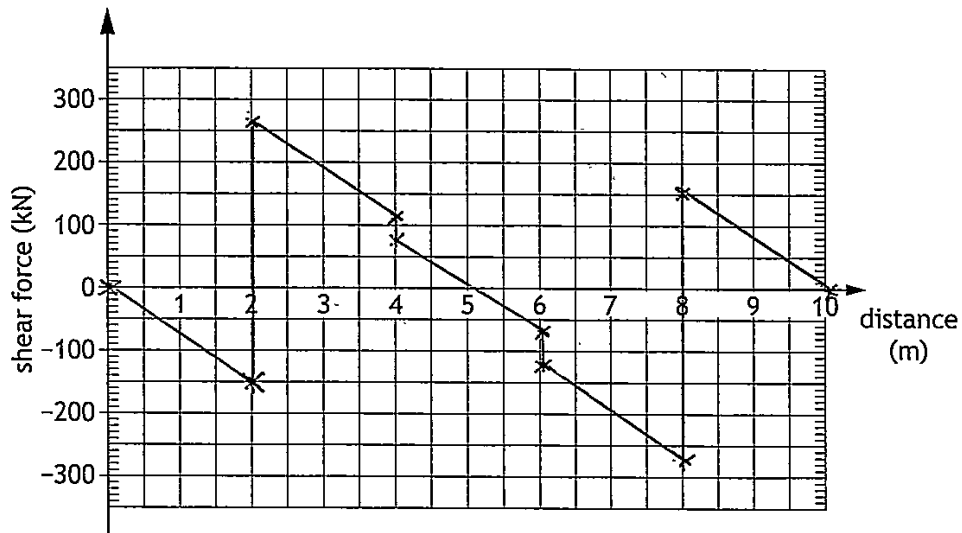
Stage	Week																	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	
A	A	A	A	A	F	F	F											
B	B																	
C		C	C	C	C													
D					D	D	D	D	D	D	D	F	F	F				
E						E	E	E										
F									F	F	F	F	F	F				
G						G	G	G	G	G	G	G	G	G				
H																H	H	H

(ii) Critical path B, C, E, F, H

Worksheet for question 4 (a)



Worksheet for question 9 (a)



ENTER  
NUMBER  
OF  
QUESTION

~~1)~~  

$$I_{xx} = \frac{BD^3}{12} - 4 \left( \frac{bd^3}{12} \right)$$

$$= \frac{30 \times 40^3}{12} - 4 \left( \frac{10 \times 10^3}{12} \right)$$

$$= 157 \times 10^3 \text{ mm}^4$$

2.a) Pump storage systems act like a rechargeable battery by being able to produce energy when demand is high and use surplus energy to move water back up when ~~the~~ demand is low, this means they must be included as they are able to flexibly meet demand and are environmentally friendly.

b) ~~1)~~  $0.94 = \frac{E_{out}}{1}$   $0.96 = \frac{E_{out}}{0.94}$

$E_{out} = 0.94$   $E_{out} = 0.9024$

~~$0.9024 = \frac{E_{out}}{0.85}$~~

~~$E_{out} = 0.767072$~~   $0.97 = \frac{E_{out}}{0.9024}$

$E_{out} = 0.875328$

$0.97 = \frac{E_{out}}{0.875328}$

$E_{out} = 0.84906816$

$\therefore E_{out} = 0.85 / 85\%$

ENTER  
NUMBER  
OF  
QUESTION

3.a) capital costs are fixed one time expenses e.g. purchase of land or price of installation.  
there will be a decrease in capital costs due to more companies starting to sell the various components resulting in more competition and therefore due to more competitive prices, <sup>they</sup> will lower.

c) They would ~~be~~ distribute more workers and supplies to the critical activities to ensure they are not delayed. They can either spend extra to achieve this or relocate them from other non-critical activities.

4.a) working:  $V_{CC} = I_D R_L$   
 $12 = I_D \times 5.6$   
 $I_D = 2.1 \text{ A}$   
from graph  $V_{GS} = 5 \text{ V}$

ENTER  
NUMBER  
OF  
QUESTION

$$4.b) \quad V_{GS} = 5V \therefore V_2 = 5V \quad \frac{V_2}{V_1} = \frac{R_2}{R_1}$$

$$V_1 = 12 - 5 = 7V \quad \frac{5}{7} = \frac{R_2}{R_1} \quad (1)$$

$$\frac{1}{100} = \frac{1}{R_1} + \frac{1}{R_2} \quad (2)$$

$$\frac{1}{100} - \frac{1}{R_2} = \frac{1}{R_1}$$

$$R_1 = 100 - R_2$$

$$\frac{5}{7} = \frac{R_2}{100 - R_2} \quad (2) \text{ into } (1)$$

$$\frac{500 - 5R_2}{7} = R_2$$

$$\frac{500}{7} - \frac{5R_2}{7} = R_2$$

$$\frac{500}{7} = R_2 + \frac{5R_2}{7}$$

$$\frac{500}{7} = R_2 \left(1 + \frac{5}{7}\right)$$

$$R_2 = \underline{42k\Omega}$$

$$\frac{5}{7} = \frac{42}{R_1}$$

$$R_1 = \underline{59k\Omega}$$

ENTER  
NUMBER  
OF  
QUESTION

5)  $V_{DS} \approx 12V$

$I_{DS} = 3A$

TON = 2  $\mu$ s

TOFF = 28  $\mu$ s

$$E = \frac{1}{2} 12 (24 \times 10^{-9} \times 3 + 28 \times 10^{-9} \times 3)$$

$$E = 9.36 \times 10^{-7} J$$

In 5ms on + off 12 times

so 1ms 2.4 times

$\therefore$  1s 2400 times on + off so  $\div 2$   
1200

$$P = 9.36 \times 10^{-7} \times \del{2400} 1200$$

$$P \approx \underline{1.1 \times 10^{-3} W}$$

ENTER  
NUMBER  
OF  
QUESTION

6.a) from graph:  $v_2 = -9.0\text{V}$ ,  $t = 0.20\text{s}$

$$\Delta v_{\text{out}} = -\frac{1}{RC} \int v_{\text{in}} dt$$

$$-9.0 = -\frac{1}{5.6 \times 10^3 \text{C}} \int 5 dt$$

$$-9.0 = -\frac{1}{5.6 \times 10^3 \text{C}} \times 5t + C$$

$$-9.0 = -\frac{1}{5.6 \times 10^3 \text{C}} \times 5 \times 0.20 \quad \left\{ \begin{array}{l} t=0, v_2 = 0 \\ \therefore C=0 \end{array} \right.$$

$$\frac{1}{5.6 \times 10^3 \text{C}} = \frac{-9.0}{5 \times 0.20}$$

$$C = \underline{2.0 \times 10^{-5} \text{F}}$$

6.b)  $3.3 \times 10^{-5} > 2.0 \times 10^{-5}$

$\epsilon$  is larger so time to saturate will be less.

6.c)  $v_{\text{out}} = -\frac{1}{RC} \int v_2 dt$

$$v_{\text{out}} = -\frac{1}{9.1 \times 10^3 \times 100 \times 10^{-9}} \times \int \frac{-125v_{\text{in}} t}{14} dt$$

$$v_{\text{out}} = -\frac{1 \times 10^5}{91} \times \frac{-125v_{\text{in}} t^2}{2 \times 14}$$

$$\underline{v_{\text{out}} = 4906 v_{\text{in}} t^2}$$

$$v_2 = -\frac{1}{RC} \int v_{\text{in}} dt$$

$$v_2 = -\frac{1}{5.6 \times 10^3 \times 2.0 \times 10^{-5}} \times \int v_{\text{in}} dt$$

$$v_2 = -\frac{125 v_{\text{in}} t}{14}$$

$$(C=0)$$

ENTER  
NUMBER  
OF  
QUESTION

$$7a) I = 21 \times 10^3 \text{ mm}^4$$

$$L = 1.50 \text{ m}$$

$$a = 0.50 \text{ m}$$

$$P = \frac{190}{2} = 95 \text{ kg}$$

$$\sigma = 200 \text{ kN mm}^{-2}$$

$$\delta_{\text{max}} = \frac{95 \times 0.50 \times 10^{-3}}{24 \times 200 \times 10^3 \times 21 \times 10^3} \times (3(1.50 \times 10^{-3})^2 + 4(0.50 \times 10^{-3})^2)$$

$$\delta_{\text{max}} = 2.7 \times 10^{-18} \text{ m}$$

$$7b) M = -Pa$$

$$M = -95 \times 0.50$$

$$M = -47.5 \text{ Nm}$$

$$\frac{M}{I} = \frac{\sigma}{y}$$

$$\frac{-47.5 \times 10^{-3}}{21 \times 10^3} = \frac{\sigma}{14.5}$$

$$\sigma = -3.3 \times 10^{-5} \text{ N mm}^{-2}$$

c) It is suitable because  
the maximum  $\sigma$  is  $-3.3 \times 10^{-5} \text{ N mm}^{-2}$  ?  
which is less than  $680 \text{ N mm}^{-2}$ .

ENTER  
NUMBER  
OF  
QUESTION

8.a) B-busbar, acts as a joining point/junction for multiple lines

A-circuit breaker?, allows current to be cut off in the event of an emergency.

8.b)

$P_{core} = 2.5 \text{ kW}$

$R_1 = 482 \text{ m}\Omega$

$R_2 = 1.74 \text{ m}\Omega$

$V_2 = 1.5 \text{ kV}$

$V_1 = 25 \text{ kV}$

$P_{in} = 5.2 \text{ MVA}$

$I_1 = \frac{P_{in}}{V_1}$

$I_1 = \frac{5.2 \times 10^6}{25 \times 10^3}$

$I_1 = 208 \text{ A}$

~~$P_{out}$~~

$P_{in} = P_{out} + P_{core} + P_1 + P_2$

~~$\frac{I_1 V_1}{1000}$~~   $= \frac{I_2 V_2}{1000} + P_{core} + I_1^2 R_1 + I_2^2 R_2$

$5.2 \times 10^6 = I_2 \times 1.5 \times 10^3 + 2.5 \times 10^3$

$+ 208^2 \times 482 \times 10^{-3}$

$+ I_2^2 \times 1.74 \times 10^{-3}$

$0 = 1.74 \times 10^{-3} I_2^2 + 1.5 \times 10^3 I_2$

$- 5176646.752$

$I_2 = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$

$I_2 = \frac{-1.5 \times 10^3 \pm \sqrt{(1.5 \times 10^3)^2 - 4 \times 1.74 \times 10^{-3} \times (-5176646.752)}}{2 \times 1.74 \times 10^{-3}}$

$2 \times 1.74 \times 10^{-3}$

$I_2 = 3418 \text{ A or } -757703 \text{ A}$

$I_2 = 3418 \text{ A} = 3400 \text{ A}$

$P = I^2 R$

$P = 3418^2 \times 1.74 \times 10^{-3}$

~~$P = 2.0 \times 10^4 \text{ W}$~~

~~$P = \frac{V^2}{R}$~~   
 ~~$P = \frac{(1.5 \times 10^3)^2}{1.74 \times 10^{-3}}$~~

1511.962123

ENTER  
NUMBER  
OF  
QUESTION

8.c) when the duty value is varied  
the period will too, for example  
duty value increases, period will  
increase

8.d) within the program.  
since it is calculated during each  
loop it will account for any  
unexpected changes and so will  
be more accurate.

8.e)  $\theta = 20^\circ$   $P = 2\pi nT$

$$80 \times 10^3 = 2\pi \times \frac{1800}{60} \times T$$

$$T = \underline{424.41318 \text{ Nm}}$$

~~$480 \times 60 = 80 \times D$~~   
 ~~$D = 376$~~

~~$876 \times 80 = 480 \times D$~~   
 ~~$D = 640 \text{ mm}$~~

$480 \text{ mm} = 60$

$360 \text{ mm} = 45$

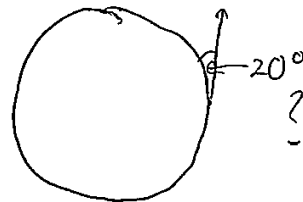
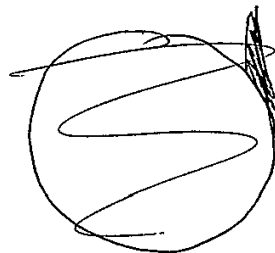
$D = 360 \text{ mm}$

$r = 180 \text{ mm}$

$T = Fr$

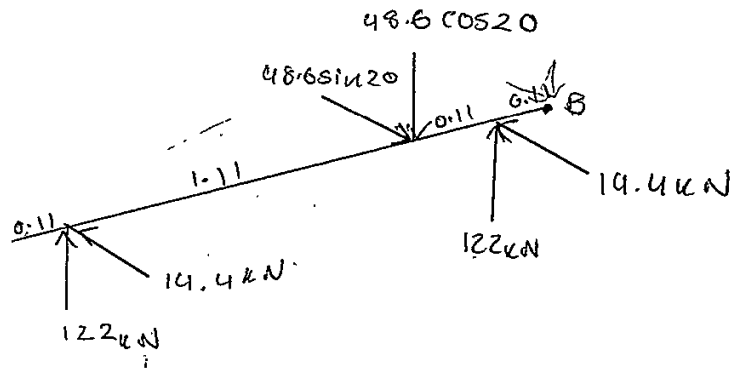
$424.41318 = F \times 180 \times 10^{-3}$

$F = \underline{2400 \text{ N}}$

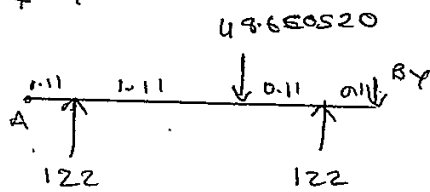


ENTER NUMBER OF QUESTION

8.f)



A-Y



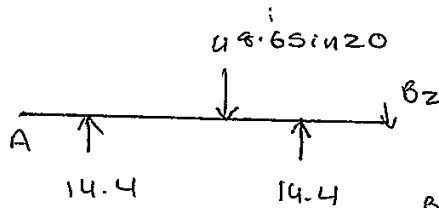
From A:

$$\sum MCW = \sum MACW$$

$$1.22 \times 48.6 \cos 20 + B_y \times 1.44 = 0.11 \times 122 + 122 \times 1.33$$

$$B_y = 83.308156 \text{ kN} \downarrow$$

X-Z



From A:

$$\sum MCW = \sum MACW$$

$$B_z \times 1.44 + 1.22 \times 48.6 \sin 20 = 0.11 \times 14.4 + 1.33 \times 14.4$$

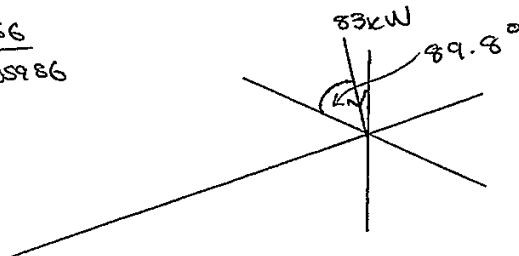
$$B_z = 0.3173205986 \text{ kN} \downarrow$$

$$B = \sqrt{83.308156^2 + 0.3173205986^2}$$

$$= 83 \text{ kN}$$

$$\theta = \tan^{-1} \frac{83.308156}{0.3173205986}$$

$$\theta = 89.8^\circ$$



ENTER  
NUMBER  
OF  
QUESTION

9.0) working

from  $R_D$ :  $\sum MCW = \sum MACW$

$$R_A \times 6 = 50 \times 2 + 25 \times 4 + 750 \times 3$$

$$R_A = \underline{408 \text{ kN}}$$

$$R_B = 50 + 25 + 750 - 408$$

$$R_B = \underline{417 \text{ kN}}$$

$$x=0, F_S = 0$$

$$x=2, F_S = -75x = -150 \text{ kN}$$

$$x=2, F_S = 408 - 75x = 258 \text{ kN}$$

$$x=4, F_S = 408 - 75x = 108 \text{ kN}$$

$$x=4, F_S = 408 - 75x - 25 = 83 \text{ kN}$$

$$x=6, F_S = 408 - 75x - 25 = -67 \text{ kN}$$

$$x=6, F_S = 408 - 75x - 25 - 50 = -117 \text{ kN}$$

$$x=8, F_S = \text{"} = -267 \text{ kN}$$

$$x=8, F_S = 408 - 75x - 25 - 50 + 417 = 150 \text{ kN}$$

$$x=10, F_S = \text{"} = 0 \text{ kN}$$

b.i)  $M = 408(x-2) - 25(x-4) - \frac{75x^2}{2}$

$$M = 408x - 816 - 25x + 100 - 37.5x^2$$

$$M = -37.5x^2 + 383x - 716$$

b.ii)

$$\frac{dM}{dx} = -75x + 383$$

$$0 = -75x + 383$$

$$75x = 383$$

$$x = \underline{5.1 \text{ m}}$$

ENTER  
NUMBER  
OF  
QUESTION

Upper threshold / max vout

$$a.c) \quad \frac{4.25-6}{R_1} + \frac{4.25-0}{R_2} + \frac{4.25-5.20}{10} = 0$$

$$\frac{-1.75}{R_1} + \frac{4.25}{R_2} - 0.095 = 0$$

$$\frac{4.25}{R_2} - \frac{1.75}{R_1} = 0.095 \quad (1)$$

Lower threshold / min vout

$$\frac{1.40-6}{R_1} + \frac{1.40-0}{R_2} + \frac{1.40-0}{10} = 0$$

$$\frac{-4.6}{R_1} + \frac{1.40}{R_2} + 0.14 = 0$$

$$\frac{1.40}{R_2} - \frac{4.6}{R_1} = -0.14 \quad (2)$$

$$1.40 \textcircled{1} - 4.25 \textcircled{2}$$

$$0R_2 + \frac{17.1}{R_1} = 0.728$$

$$R_1 = \frac{17.1}{0.728}$$

$$R_1 = \underline{23k\Omega}$$

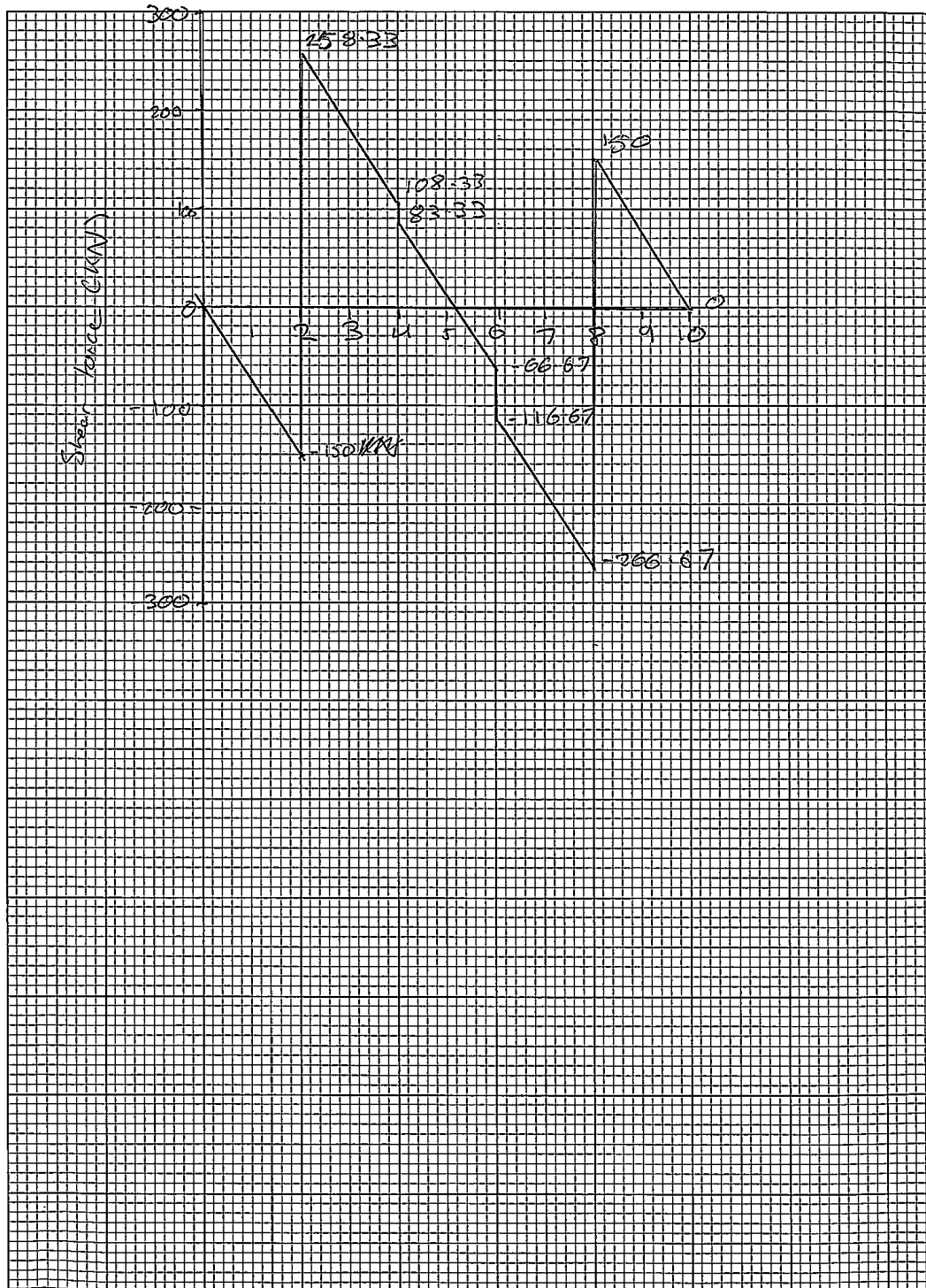
$$\frac{4.25}{R_2} - \frac{1.75}{23} = 0.095$$

$$\frac{4.25}{R_2} = \frac{787}{4600}$$

$$R_2 = \underline{25k\Omega}$$

ENTER NUMBER OF QUESTION	
a.d)	<del>10 11 12 13 14 15</del>
	107. ?
a.e)	

Enter number of question



# Candidate 2 evidence

Worksheet for question 3 (b)

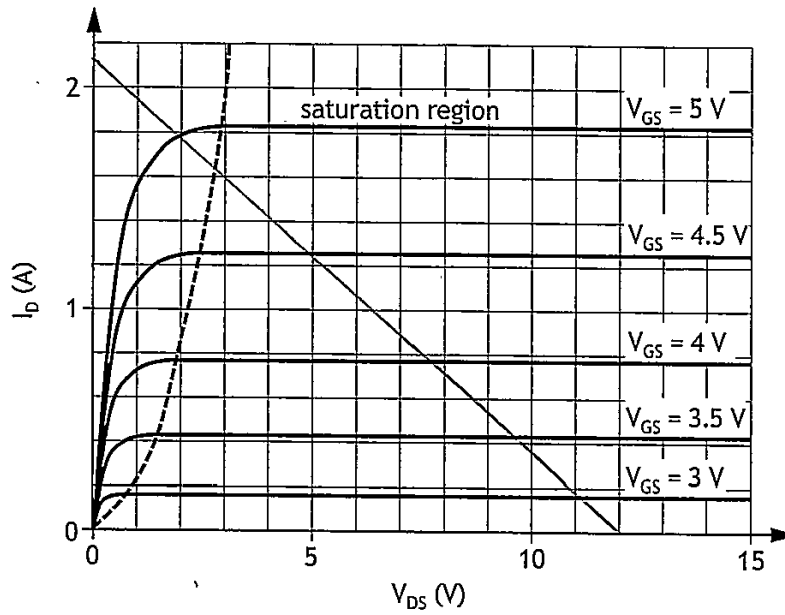
Stage	Precedents	Duration
A	----	4
B	----	1
C	B	4
D	A, B	7
E	C	3
F	E	6
G	A, C	7
H	D, F, G	3

(i)

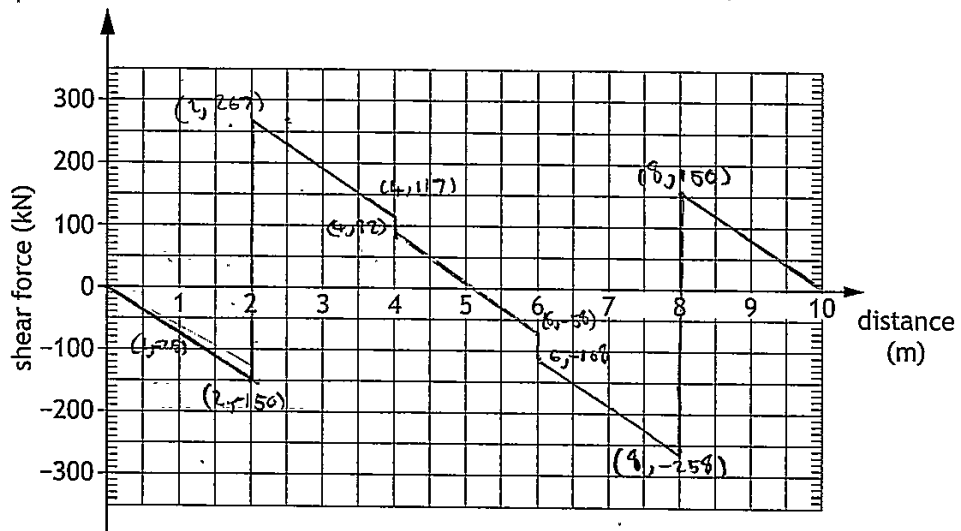
Stage	Week																
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
A					F	F	F										
B																	
C																	
D												F	F	F			
E																	
F																	
G																	
H																	

(ii) Critical path A, C, E, F, H B, C, E, F, H

Worksheet for question 4 (a)



Worksheet for question 9 (a)



ENTER  
NUMBER  
OF  
QUESTION

$$\begin{aligned}
 1. \quad I &= 4I_{\Delta} + I_{\square} + 4I_{\square} \\
 &= 4 \times \frac{10 \times 10^3}{12} + \frac{40 \times 10^3}{12} + 4 \times \frac{10 \times 10^3}{12} \\
 &= 4 \times 833.333\text{---} + 5333.33\text{---} + 4 \times 833.333\text{---} \\
 &= 60000 \text{ mm}^4
 \end{aligned}$$

2. a) hydroelectric pump storage systems are the most efficient and currently the best way to store excess electricity in the grid. when there is excess electricity it is used to pump water uphill and it can be released during the peak demand later in the day in order to alleviate the supply. They can also start generating electricity very quickly so they are very flexible in for which is perfect for supplying electricity whenever there are small spikes in demand

ENTER  
NUMBER  
OF  
QUESTION

2) Efficiency =  $0.96 \times 0.94 \times 0.97 \times 0.97 \times 100$   
 $\approx 84.94$   
 $= 84.9069 \dots$   
 $= 84.9\%$  efficient

$\Rightarrow$  0.849 units of electricity available for every 1 unit put in

3. a) Capital costs are initial, one time investments in things ~~such as~~ land, materials and infrastructure in order to begin a project.

The downward trend in capital costs is a result of the components moving from prototype to commercial production.

In the prototype stage the components are expensive as there is no production line for them, ~~and~~ machines need to be configured and workers need to be trained leading to more time and money spent by the manufacturer to make them so they have to sell them for more in order to make a profit.

In the commercial stage however, the components are ~~being~~ mass produced so they are cheaper to manufacture so the manufacturers can sell them cheaper for the same profit.

ENTER  
NUMBER  
OF  
QUESTION

3. c) The project manager can use the Gantt chart to identify the critical path and make sure that it is completed on time by making sure there is enough manpower and resources on these stages. They can also identify stages which have a float so they do not need to be completed immediately and resources can be moved from these stages to the critical path. It also helps visualise which stage is required when so the project manager can order ~~order~~ ~~prototypes of~~ components/materials for when they are needed.

4 a)  $I_D \text{ max when } V_{DS} = 0$

$$I_D = \frac{V_{GS}}{5.6}$$

$$= 2.1429 \dots$$

$$= 2.1 \text{ A}$$

$V_{GS} = 11.2 \text{ V}$   
for max output  
voltage swing

$$b) \frac{1}{100000} = \frac{1}{R_1} + \frac{1}{R_2}$$

$$V_{R2} = V_{GS} = 11.2 \text{ V}$$

$$V_{R1} = 11.2 \text{ V} \times 12.3 \mu\text{A}$$

$$= 0.13776 \text{ V}$$

ENTER  
NUMBER  
OF  
QUESTION

1a

$$\frac{V_1}{V_2} = \frac{R_1}{R_2}$$

$$\text{Sub } R_1 = \frac{9}{3} R_2$$

into

$$\frac{9}{3} = \frac{R_1}{R_2}$$

$$\frac{1}{100000} = \frac{1}{R_1} + \frac{1}{R_2}$$

$$R_1 = \frac{9}{3} R_2$$

$$\frac{1}{100000} = \frac{1}{\frac{9}{3} R_2} + \frac{1}{R_2}$$

$$\frac{1}{100000} = \frac{4}{3R_2}$$

$$R_2 = 133\,333.333\dots$$

$$= 130\text{ k}\Omega$$

$$\frac{V_1}{V_2} = \frac{R_1}{R_2}$$

$$3 = \frac{R_1}{133333.333}$$

$$R_1 = 400000$$

$$= 400\text{ k}\Omega$$

b. 9/11

$$V_{DS(\text{off})} = 12\text{ V}$$

$$T_{\text{on}} = 24 \times 10^{-9}$$

$$T_{\text{off}} = 29 \times 10^{-9}$$

$$I_{\text{DSC(on)}} = 3$$

$$E = \frac{1}{2} V_{\text{DS(off)}} (T_{\text{on}} I_{\text{DSC(on)}} + T_{\text{off}} F_{\text{DSC(on)}})$$

$$= \frac{1}{2} \times 12 ((24 \times 10^{-9} \times 3) + (29 \times 10^{-9} \times 3))$$

$$= 281.7 \times 10^{-9} \text{ J}$$

ENTER  
NUMBER  
OF  
QUESTION

$$P_{\text{switching}} = E_{\text{switching}} \times \text{frequency}$$

$$f = n \text{ per second} \quad \text{in } 10\mu\text{s}, n = 12$$

$$\text{So } 6 \cdot 015 = 12$$

then

$$15 = 1200$$

$$\text{So } f = 1200$$

$$= 936 \times 10^{-9} \times 1200$$

$$= 1123.2 \times 10^{-6}$$

$$= 1.12 \times 10^{-3} \text{ W}$$

$$6. \quad a) \quad V_2 = -\frac{1}{RC} \times \int i \, dt$$

$$-9 \text{ V} = -\frac{1}{5.6 \times 10^{-3} \times C} \times \int_0^{0.2} 5 \, dt$$

$$-9 = -\frac{1}{5.6 \times 10^{-3} \times C} \times [5t]_0^{0.2}$$

$$-9 = \frac{1}{5.6 \times 10^{-3} \times C} \times 1$$

$$C = 0.000019641 \dots$$

$$= 19.6 \mu\text{F}$$

ENTER  
NUMBER  
OF  
QUESTION

b) ~~The time taken is unchanged~~  
The time taken for the op amp to saturate is unchanged

$$\begin{aligned} \text{c) } V_1 &= -\frac{1}{R_1 C} \int u_1 dt \\ &= -\frac{1}{5 \cdot 6 \times 10^3 \times 33 \times 10^{-6}} \times \int 5 dt \\ &= -27.0562 \dots t \end{aligned}$$

$$\begin{aligned} V_{out} &= -\frac{1}{R_2 C} \int V_1 dt \\ &= -\frac{1}{9 \cdot 1 \times 10^3 \times 100 \times 10^{-9}} \times \int -27.0562 t dt \\ &= 71200.791 \dots t^2 \\ &= 71200 t^2 \end{aligned}$$

7. a)

$$\begin{aligned} P &= \frac{146}{2} \times 7.8 & I &= 21 \times 10^3 \\ &= 931 \text{ N} & E &= 200 \times 10^3 \end{aligned}$$

$$d = 500 \text{ mm}$$

$$L = 1500$$

$$\begin{aligned} \delta_{max} &= \frac{P \cdot L}{24EI} (3L^2 - 4a^2) \\ &= \frac{931 \times 1500}{24 \times 200000 \times 21000} (3 \times 1500^2 - 4 \times 500^2) \\ &= 26.55391 \dots = 26.6 \text{ mm} \end{aligned}$$

ENTER  
NUMBER  
OF  
QUESTION

7.

b)

$$\frac{M}{I} = \frac{\sigma}{y}$$

$$\frac{465500}{21000} = \frac{\sigma}{14.5}$$

$$\sigma = 321.4666\dots$$

$$= 321.4 \text{ Nmm}^{-2}$$

$$y = \frac{1}{2}d \quad I = 21000$$

$$= 14.5$$

$$m = -Pa$$

$$= -931 \times 500$$

$$= -465500 \text{ Nmm}$$

- c) At the lower end of the range the factor of safety is just over 7 with weight lifting being a high energy activity it is reasonable to assume that flex may be some more stress in the beam or ~~the~~ more weight could be ~~applied~~ <sup>applied</sup> to the ~~beam~~ <sup>bar</sup>, also due to the large weights involved failure of the bar could result in major injuries. The other end is much ~~safer~~ <sup>safer</sup> with a factor of safety of 7 meaning ~~the~~ <sup>the bar</sup> is incredibly unlikely to fail in this application.

ENTER  
NUMBER  
OF  
QUESTION

8.

a)

$$b) \text{ } P_{\text{out}} = P_{\text{in}} = 2.5 \times 10^3$$

∴

$$P = IV$$

$$5.2 \times 10^6 = I \times 25 \times 10^3$$

$$I = 208 \text{ A}$$

$$P = I^2 R$$

$$= 482 \times 10^{-3} \times 208^2$$

$$= 20853.248$$

$$P_{\text{loss in primary winding}} = 20853.248 \text{ W}$$

ENTER  
NUMBER  
OF  
QUESTION

$$P_{out} =$$

$$P_{out} = P_{in} - P_{core} - P_{loss}$$

$$= 5 \times 10^6 - 2.5 \times 10^3 - 20853249$$

$$= 4976646.752$$

$$P = IV$$

~~$$4976646.752$$~~

$$4976646.752 = 1.5 \times 10^3 \times I$$

$$I_2 = 3317.764501 \text{ A}$$

$$\text{Current in secondary winding} = 3.3 \times 10^3 \text{ A}$$

$$P = I^2 R$$

$$= (3317.7645)^2 \times 1.74 \times 10^{-3}$$

~~$$19153.15664 \dots$$~~

$$= 19153.15664 \dots$$

$$= 19 \text{ kW}$$

- c) you could take the values in the table and divide them by 255 to get a ratio. Then, these could be multiplied by a multiplier to achieve the desired period

ENTER  
NUMBER  
OF  
QUESTION

d) reading them from the table would produce a more accurate waveform as the calculations might produce values slightly higher or lower than the max value or lower than 0 causing there to be an error with the output

e)

$P = 2 \pi n T$  ~~is not~~

$n = \text{number of teeth}$

$$V_{in} \times n_{in} = V_{out} \times n_{out}$$

$$1800 \times 60 = V_{out} \times 50$$

$$V_{out} = 2160$$

$$V_{in} \times n_{in} = V_{out} \times n_{out}$$

$$2160 \times 50 = V_{out} \times 45$$

$$V_{out} = 2400 \text{ rev min}^{-1}$$

$$= 40 \text{ rev s}^{-1}$$

$$P = 2 \pi n T$$

$$3000 = 2 \pi \times 40 \times T$$

$$T = 319.30989 \dots \text{ Nm}$$

$$= 319 \text{ Nm}$$


$$T = F r$$

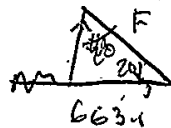
$$319.309 \dots = F \times 0.49$$

$$F_T = 651.65 \dots$$

$$= 652 \text{ N}$$

ENTER  
NUMBER  
OF  
QUESTION

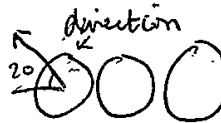
  $F_T = 663.1 \dots$



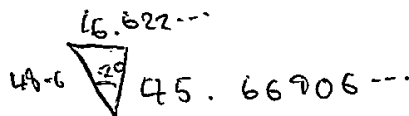
then  $F = \frac{F_T}{\sin 20}$   
 $= \frac{663.1 \dots}{\sin 20}$   
 $= 1938.909 \dots$

or

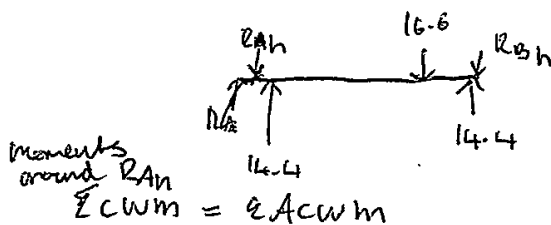
$\approx 1.9 \times 10^3 \text{ N}$



f)



horizontal



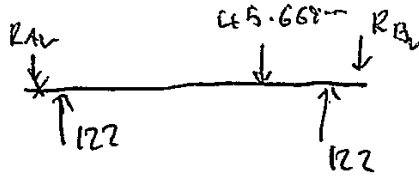
~~$R_B \times 1.44 = 14.4 \times 0.11 + 16.6 \times 1.22 + 14$~~

$R_B \times 1.44 + 16.6 \times 1.22 = 14.4 \times 0.11 + 14.4 \times 1.33$

$R_B = 0.336111 \dots \text{ kN}$

ENTER  
NUMBER  
OF  
QUESTION

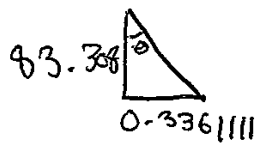
Vertical:



$$\sum CWm = \sum ACWm$$

$$R_{Bv} \times 1.44 + 45.66 \times 1.22 = 122 \times 1.33 + 122 \times 0.11$$

$$R_{Bv} = 83.308 \dots \text{ kN}$$



$$a^2 + b^2 = c^2$$

$$83.308^2 + 0.3361111^2 = c^2$$

$$c = 83.30898 \dots$$

~~83~~

$$\tan \theta = \frac{0.3361111}{83.308}$$

$$\theta = 0.23116 \dots$$

$$\text{so } R_A = 83.3 \text{ kN } \swarrow \text{ } 0.23^\circ$$

ENTER  
NUMBER  
OF  
QUESTION

9. a)  $\sum CWm = \sum ACWm$

$$25 \times 2 + 750 \times 3 + 50 \times 4 = R_B \times 6$$

$$R_B = 416.666 \dots$$

$$= 417 \text{ kN}$$

$$\sum \uparrow = \sum \downarrow$$

$$750 + 25 + 50 = 417 + R_{MA}$$

$$R_A = 408 \text{ kN}$$

b) i) ~~between 4 ≤ 6 ≤ 6~~

$$M = 408(x+2) - \frac{25x^2}{2} - \frac{75 \times (x+4)^2}{2} - 25x$$

$$M = 408x + 816 - \frac{75x^2}{2} + 300x + 600 - 25x$$

$$M = 693x - \frac{75x^2}{2} + 600$$

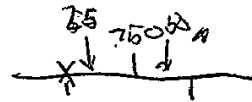
ii)  $\frac{dM}{dx} = 0$

$$0 = 693 - 75x$$

$$x = 9.1066 \dots$$

$$= 9.1 \text{ m}$$

$$408x + \frac{75x^2}{2} - 25x$$



ENTER  
NUMBER  
OF  
QUESTION

9. bi)  $M =$  between  $4 \leq x \leq 6$   
 $409x - \frac{75x^2}{2} - 25x$

$$M = 383x - \frac{75x^2}{2}$$

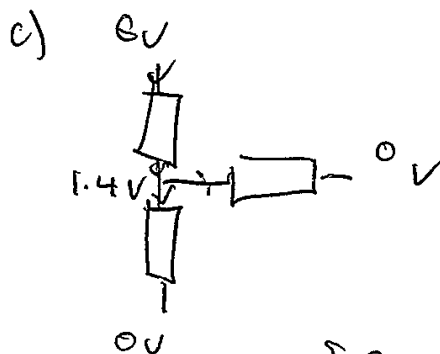
ii)  $\frac{dM}{dx} = 0$  at max  $M$

$$0 = 383 - 75x$$

$$75x = 383$$

$$x = \cancel{5.1} 5.10666\dots$$

$$= 5.1 \text{ m}$$



$$\frac{6 - 1.4}{R_1} = \frac{1.4}{10} + \frac{1.4}{R_2}$$

$$\frac{4.6}{R_1} = 0.14 + \frac{1.4}{R_2} \text{ (1)}$$

sub (2) into (1)

$$\frac{4.6}{R_1} = \frac{6 - 1.4}{R_1} + \frac{5.2 - 4.25}{10} \text{ (2)}$$

4.6

ENTER  
NUMBER  
OF  
QUESTION

$$\frac{5.2}{R_2} = \frac{1.75}{R_1} + \frac{0.95}{10} \quad \times 70 \quad \times i = 4$$

~~$$\frac{4.6}{R_1}$$~~

$$\frac{1.4}{R_2} = \frac{4.6}{R_1} \sim 0.14$$

~~$$\frac{7.856}{R_2} = \frac{12.74}{R_1} + \frac{6.916}{10}$$~~

~~$$\frac{10.122}{R_2} = \frac{33.488}{R_1}$$~~

~~$$\frac{7.28}{R_2} = \frac{24.5}{R_1} + \frac{133}{10}$$~~

$$\frac{7.28}{R_2} = \frac{23.42}{R_1} \sim 0.729$$

$$0 = \frac{-21.47}{R_1} + 0.961$$

$$R_1 = \frac{24.936120 \dots}{0.961} = 24.92 \text{ kV}$$

ENTER  
NUMBER  
OF  
QUESTION

$$\frac{5.2}{R_2} = \frac{1.73}{249} \pm \frac{0.45}{10}$$

$$R_2 = 31.4615 \\ = 31.5 \Omega$$

$$d) \frac{1.1}{10} \times 100 \\ = 10\%$$

e) to reduce the ~~calculated~~ error, the program could ~~read the~~ count over a longer period of time

# Candidate 3 evidence

Worksheet for question 3 (b)

Stage	Precedents	Duration
A	----	4
B	----	1
C	B	4
D	A, B	7
E	C	3
F	E	6
G	A, C	7
H	D, F, G	3

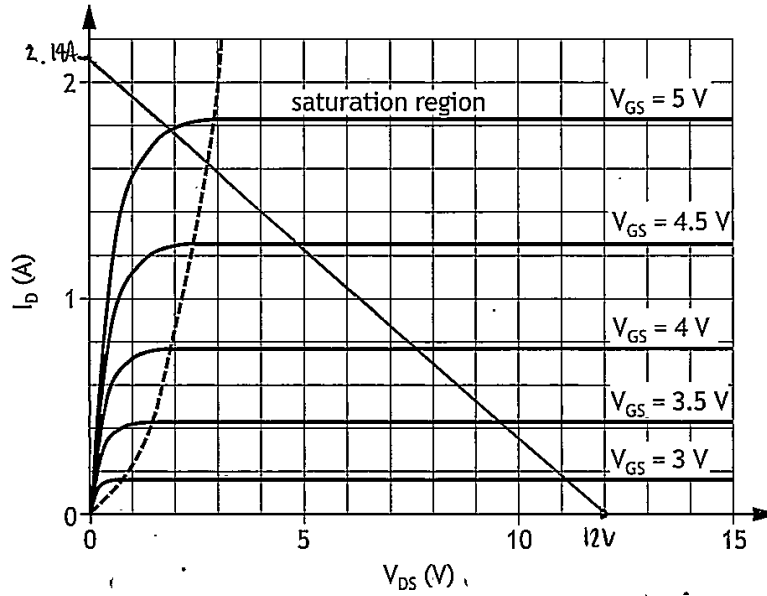
(i)

	Week																
Stage	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
A					F	F	F										
B																	
C																	
D												F	F	F			
E																	
F																	
G																	
H																	

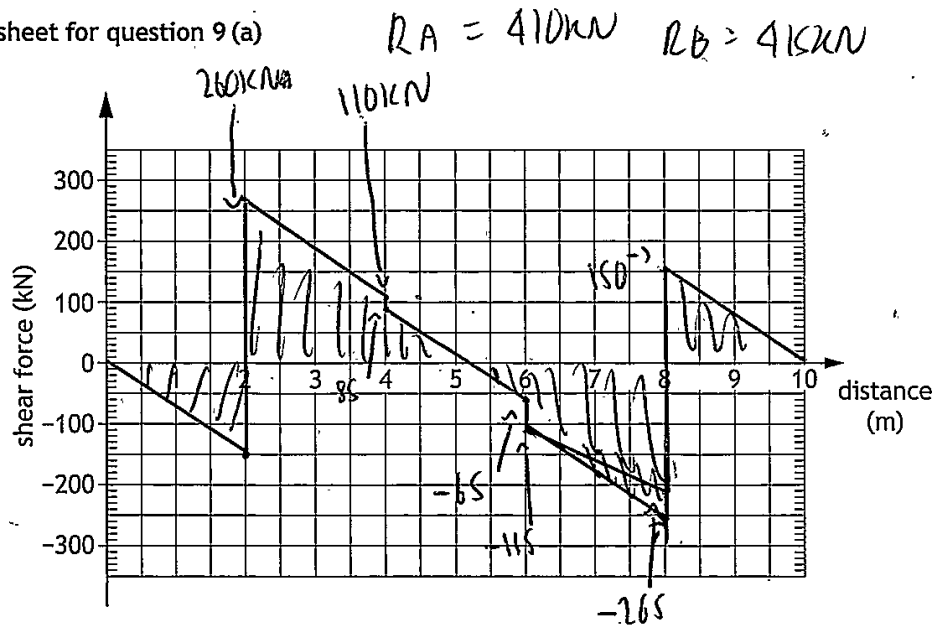
(ii) Critical path ~~BCGH~~ BCGH

\* the two week float at end is not ideal as without the product can be finished earlier.

Worksheet for question 4 (a)



Worksheet for question 9 (a)



ENTER  
NUMBER  
OF  
QUESTION

①

$$I_{xx}(R_1) = \frac{bd^3}{12} = \frac{30 \times 10^3}{12} = 2500 \text{ mm}^4$$

$$I_{xx}(R_2) = \frac{bd^3}{12} = \frac{10 \times 20^3}{12} = \frac{20,000}{3} \text{ mm}^4$$

$$I_{xx}(T_1) = \frac{bh^3}{12} = \frac{10 \times 10^3}{12} = \frac{2500}{3} \text{ mm}^4$$

$$R_1 = R_3, \quad T_1 = T_2 = T_3 = T_4$$

$$I_{xx} = 2(I_{xx}(R_1)) + I_{xx}(R_2) + 4(I_{xx}(T_1))$$

$$= 2(2500) + \frac{20,000}{3} + 4\left(\frac{2500}{3}\right)$$

$$= 1.5 \times 10^4 \text{ mm}^4$$

$$\underline{I_{xx} = 1.5 \times 10^4 \text{ mm}^4}$$

2) a)

Hydro-electric pump storage systems are ~~not~~ rapid-acting and can provide lots of energy quickly, but can't be sustained for too long.

The UK power system relies on renewables for part of it's supply. These don't always have reliable, consistent output so pumped storage can be used to ~~meet~~ meet the difference.

ENTER  
NUMBER  
OF  
QUESTION

2) a)

◦ When the power demand is at its peak, pumped storage is one of few outputs that can ~~be~~ have its output adjusted quickly enough to meet the demand.

2) b)

$$\frac{\text{Overall efficiency}}{100} = \left( \frac{96}{100} \times \frac{94}{100} \times \frac{(100-3)}{100} \times \frac{(100-3)}{100} \right)$$

$$= 0.78$$

$$\text{overall efficiency} = 100 \times 0.78$$

$$= 78\%$$

Therefore 0.78 units of electricity is available from the system for every 1 unit of electricity produced prior to storage.

3) a)

◦ Capital costs are fixed, one-time expenses incurred on the purchase of land, tools, equipment etc. to complete a project.

◦ The initially high capital cost is due to the initial prototype. The company creating the products may wish to experiment with different manufacturing strategies or materials to find what ones give the best quality product/profit.

◦ Frequent design and manufacture technique changes initially could drive the capital costs up, but as the product is refined, better, ~~less cost~~ more cost efficient methods are found, decreasing capital cost.

ENTER  
NUMBER  
OF  
QUESTION

3)a)

- Heading into the pre-commercial stage the changes to the product will decrease, and at the commercial stage the process is fully refined so at it's cheapest.
- (There may also be discounts for buying materials etc from same people for long time). ~~After the start~~ ~~must only be purchased~~
- Some things are reusable from the prototype stage so don't have to be bought again e.g. land (factory) and tools.

3)c)

- The project manager can assess what ~~projects~~ tasks have a lot of float time and transfer resources/manpower from non-critical tasks to tasks on the critical path to avoid delays.
- The project manager can see when each task begins, if ~~resources~~ spare resources can be transferred and ~~when to order~~ knows when to order each equipment/materials for each task by. They can carefully monitor material delivery for all tasks, but especially those on the critical path.

4)a)

When ~~DEQ~~  $V_{DS} = 0$

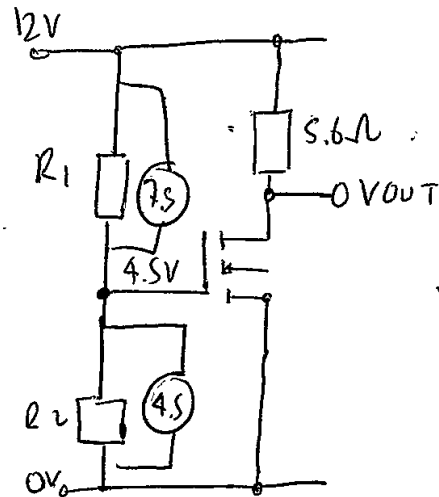
$$V = IR \quad I = \frac{12}{5.6}$$

$$I = \frac{V}{R} \quad = 2.14 A$$

suitable value:  $V_{GS} = \underline{4.5V}$

ENTER  
NUMBER  
OF  
QUESTION

4) b)



$$V_{GS} = 4.5V$$

$$\frac{V_1}{V_2} = \frac{R_1}{R_2} \quad \frac{7.5}{4.5} = \frac{R_1}{R_2} \quad R_1 = \frac{7.5R_2}{4.5}$$

$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2}$$

$$\frac{1}{100,000} = \frac{1}{R_1} + \frac{1}{R_2}$$

$$\frac{1}{100,000} = \frac{4.5}{7.5R_2} + \frac{1}{R_2}$$

$$\frac{1}{100,000} = \frac{1}{R_2} \left( \frac{4.5}{7.5} + 1 \right)$$

$$\frac{R_2}{100,000} = \frac{4.5}{7.5} + 1$$

$$R_2 = 100,000 \left( \frac{4.5}{7.5} + 1 \right)$$

$$R_2 = 160k\Omega$$

$$R_1 = \frac{7.5}{4.5} \times 160,000 \quad R_1 = 267k\Omega$$

ENTER  
NUMBER  
OF  
QUESTION

5)

$$\begin{aligned}
 E_s &= \frac{1}{2} V_{DS(off)} (T_{(on)} I_{D(on)} + T_{(off)} I_{D(on)}) \\
 &= \frac{1}{2} (12) ((24 \times 10^{-9} \times 3) + (28 \times 10^{-9} \times 3)) \\
 &= 6 (1.56 \times 10^{-7}) \\
 &= 9.36 \times 10^{-7} \text{ J}
 \end{aligned}$$

$$P_s = E_s \times \text{frequency}$$

$$\begin{aligned}
 1 \text{ ms} &= 1 \times 10^{-3} \text{ s} \\
 1000 \text{ ms} &= 1 \text{ s}
 \end{aligned}$$

In 10ms, the MOSFET switched on and off  
12 times

$$\text{so } 1 \text{ ms} = 1.2 \text{ times.}$$

$$\text{therefore } 1 \text{ s} = 1000 \text{ ms} = 1200 \text{ times}$$

$$\text{therefore } f = 1200 \text{ Hz}$$

$$P_s = E_s \times \text{frequency}$$

$$\begin{aligned}
 P_s &= 9.36 \times 10^{-7} \times 1200 = 0.0011232 \text{ W} \\
 &= \underline{1.1 \times 10^{-3} \text{ W (2sf)}}
 \end{aligned}$$

ENTER  
NUMBER  
OF  
QUESTION

6) a)

$$DV_{OUT} = -\frac{1}{R_2 C} \int v_{in} dt$$

$$-9 = -\frac{1}{5600 C} \times 0.2 \int 5 dt$$

$$-9 = -\frac{1}{5600 C} \times [5t]_0^{0.2}$$

$$9 = \frac{1}{5600 C} \times 1$$

$$50400 C = 1$$

$$C = \frac{1}{50400}$$

$$C = 1.984126 \times 10^{-5} F$$

$$C = 2 \times 10^{-5} F (2 \mu F)$$

b)  $33 \times 10^{-6} > 2 \times 10^{-5}$ , therefore, the capacitor has a larger value for capacitance, and time to saturate increases ~~as the capacitor~~

to

c)  ~~$\Delta V_{OUT} = -\frac{1}{R_2 C} \int v_{in} dt$~~

~~$\Delta V_2 = \frac{1}{5600 C}$~~

~~From start, as  $V_2$  will change due to the capacitor value changing, 't' also changes.~~

~~$\Delta V_2 = -\frac{1}{R_2 C} \int v_{in} dt$~~

~~$$\Delta V_2 = \frac{1}{5600 \times 33 \times 10^{-6}} \times 0.2 \int 5 dt$$~~
~~$$= \frac{1200}{431} \times 5t$$~~

ENTER  
NUMBER  
OF  
QUESTION

6) c)  $\delta v_2 = \frac{-1250}{231} \times 5t$

$\Delta v_{out} = \frac{-1}{2e} \times \int_0^t \delta v_2 dt$

$\frac{1}{9100 \times 100 \times 10^{-9}} \times \int_0^t \frac{-1250}{231} dt$

$v_2 = \frac{-6250}{231} t$

$= \frac{-1}{9100 \times 100 \times 10^{-9}} \times \int_0^t \frac{-6250}{231} dt$

$= \frac{-1}{9100 \times 100 \times 10^{-9}} \times \left[ \frac{-6250}{462} t^2 \right]_0^t$

cancel (-)

$= \frac{1}{9100 \times 100 \times 10^{-9}} \times \frac{6250}{462} t^2$  6) c) at end

$\Delta v_{out} = 14866 t^2$

7) a)

$\bar{\sigma}_{max} = \frac{Pa}{24EI} (3L^2 - 4a^2)$

$\bar{\sigma}_{max}$

$p = 931N$

$a = 500mm$

$I = 21 \times 10^3 mm^4$

$E = 200 kN/mm^2$

$L = 1500mm$

mass (total) = 190kg.

$w = mg$

$w = 190 \times 9.8$

$= 1862N$

do I consider bar as 0 weight?

$\dots \frac{w}{L} = P$

$p = 931N$

ENTER  
NUMBER  
OF  
QUESTION

7)(a)

$$P = 931 \text{ N}$$

$$a = 500 \text{ mm}$$

$$I = 21 \times 10^3 \text{ mm}^4$$

$$E = 200,000 \text{ Nmm}^{-2}$$

$$L = 1500 \text{ mm}$$

$$\sigma = \frac{Pa}{24EI} (3L^2 - 4a^2)$$

$$\sigma = \frac{931 \times 500}{24 \times 200,000 \times 21 \times 10^3} (3(1500)^2 - 4(500)^2)$$

$$\sigma = 26.6 \text{ mm (3sf)}$$

$$\sigma = 26.55381944$$

$$\sigma = 26.6 \text{ mm (3sf)}$$

7)(b)

$$\frac{\text{Stress (max)}}{\text{Strain}} = \frac{M_{max}}{I}$$

$$\sum \uparrow F = \sum \downarrow F$$

$$931 \times 2 = F \times 2$$

$$F = 931$$

$$M = 931x - 931(x - 0.5)$$

because  $x = 0.5$

$$= 931x - 931x + 465.5$$

$$= 465.5 \text{ Nm}$$

$$M = 465.5 \text{ Nm}$$

$$M = F \times d$$

$$= 931 \times 0.5 = 465.5 \text{ Nm}$$

$$y = \frac{29}{2}$$

$$y = 14.5 \times 10^{-3} \text{ m}$$

ENTER  
NUMBER  
OF  
QUESTION

7) b)

max at  $-Pa$ 

$$a = 500 \text{ mm}$$

$$p = 931 \text{ N}$$

$$M = -(931 \times 500)$$

$$= -465500 \text{ Nmm}$$

max M

$$\text{max stress} = \frac{\text{max}(M)y}{I}$$

$$y = \frac{24}{2} = 12 \text{ mm}$$

$$= \frac{-465500 \times 12}{I}$$

$$I = 21 \times 10^3$$

$$\sigma = 321.416 \text{ Nmm}^{-2}$$

$$\sigma_{\text{max}} = 321 \text{ Nmm}^{-2}$$

$$c) \quad \sigma_{\text{max}} = 321 \text{ Nmm}^{-2}$$

At low ends of the range, the low-alloy steel is not suitable I believe. This is due to the  $F_{oc}$  being low (2.1) and the risk of ~~very~~ serious injury if ~~fails~~ the bar fails high.  $\left(\frac{680}{321} = 2.1\right)$   $\rightarrow \sigma_{\text{max}}$  too close to ~~ultimate~~ ~~value~~ <sup>ultimate value</sup>.

At high ends of the range, the steel is suitable as  $F_{oc}$  can go up to 7.5, and the lifter is a lot safer.  $\left(\frac{2400}{321} = 7.5\right)$

ENTER  
NUMBER  
OF  
QUESTION

8) a)

~~A & B are~~ ~~drivers.~~ They are  
~~required to provide the necessary inputs to~~  
~~actually work the motors.~~

A is a full-wave rectifier, and it changes  
 AC input into DC input without losing ~~any~~  
~~reducing~~ any power. ~~The motors can run on~~  
~~AC because then the direction will be~~  
~~continually changing. This requires DC input.~~

The power is then transmitted in DC form.

'B' changes ~~the~~ ~~it~~ ~~to~~ from DC to AC.

B is an inverter. It ~~is~~ changes the DC  
 back to AC so the motors etc can operate  
 with their required AC input.

~~(A)~~ Both ensure the components are run using  
 the correct, AC or DC.

Choice of

ENTER  
NUMBER  
OF  
QUESTION

8b)

$$R_2 = 1.74 \times 10^{-3} \Omega$$

$$V_{OUT} = 1500V$$

$$V = IR$$

$$1500 = I \times 1.74 \times 10^{-3}$$

$$I = 862068.9655$$

$$I = 862kA \text{ (3sf)}$$

$$P = I^2 R$$

$$P = 862^2 \times 1.74 \times 10^{-3}$$

$$= (862 \times 10^3)^2 \times 1.74 \times 10^{-3}$$

$$= 1.3 \times 10^9 W \text{ (2sf)}$$

$$P = IV$$

$$5.2 \times 10^6 = I \times 25 \times 10^3$$

$$I = 208A$$

ENTER  
NUMBER  
OF  
QUESTION

8) b)

~~secondary winding resistance~~

~~$1.74 \text{ m}\Omega$  ?~~

~~definitely 16.75 mA~~

~~SD  $1.74 \times 10^{-3} \Omega$~~

~~$V = IR$~~

~~$V_{OUT} = 1500 \text{ V}$~~

~~$1500 = 1.74 \times 10^{-3} I$~~

~~$I = 8.62 \times 10^5 \text{ A}$~~

~~$P = IV$   
 $1500 =$~~

~~$P = I^2 R$  large.~~

~~INPUT~~

~~$P = IV$~~

~~$5.2 \times 10^6 = I \times 25000$~~

~~$I = 208 \text{ A}$~~

~~$P = I^2 R$  (coil 1)~~

~~$P = 4 \times 208^2 \times 482 \times 10^{-3}$~~

~~$= 2.1 \times 10^6 \text{ W}$~~

ENTER  
NUMBER  
OF  
QUESTION

8c) The period of the PWM signal matches the period of the AC output signal.

Period can be changed by changing the frequency of the signal ( $T = \frac{1}{f}$ )

8d) the second method would be the most accurate. This is because the calculations being done in the program would mean no rounding took place and the data is most accurate. Also, human error is somewhat eliminated.

8e)

$$P = \frac{2\pi I N T}{60} \dots 80,000 = \frac{1800 \times 2\pi}{60} \times T$$

$$T = 424 \text{ Nm}$$

~~left gear on bogie~~

right gear on bogie frame.

$$\frac{T_2}{T_1} = \frac{D_2 N_2}{D_1 N_1}$$

$$\frac{T_2}{T_1} = \frac{D_2 N_2}{D_1 N_1} \frac{90}{60} = \frac{T_2}{424} = \frac{50}{60}$$

$$T_2 = 353 \text{ Nm}$$

$$\frac{T_2}{T_1} = \frac{N_2}{N_1} \quad \frac{T_2}{353} = \frac{45}{50}$$

$$T_2 = 318 \text{ Nm}$$

ENTER  
NUMBER  
OF  
QUESTION

8)e)

$$T = Fr$$

$$218 = Fx$$

$$P = \frac{2\pi NT}{60}$$

$$80,000 = \frac{2\pi \times 1800}{60} \times T$$

$$T = 424 \text{ Nm}$$

$$\frac{D_2}{D_1} = \frac{N_2}{N_1} \quad \frac{D_2}{480} = \frac{50}{60}$$

$$D_2 = 400 \text{ mm}$$

$$\frac{D_2}{D_1} = \frac{N_2}{N_1}$$

$$\frac{D_2}{400} = \frac{45}{50}, \quad D_2 = 360 \text{ mm}$$

$$\Rightarrow R = 180 \times 10^{-3} \text{ m}$$

$$T = Fr$$

$$424 = F \times 180 \times 10^{-3}$$

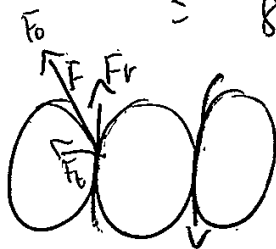
$$F = 2353.55556$$

$$= 2400 \text{ N (2sf)}$$

$$Fr = Ft \tan(20)$$

$$= 2400 \tan(20)$$

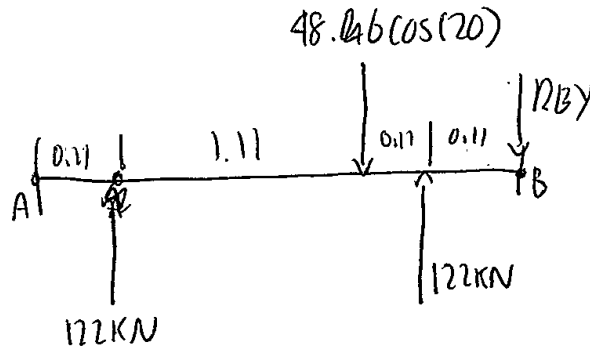
$$= 874 \text{ N (3sf)}$$



$$F_0 = \text{total force}$$

ENTER NUMBER OF QUESTION

8)(f)



moments about A

$$\sum CW M = \sum ACW M$$

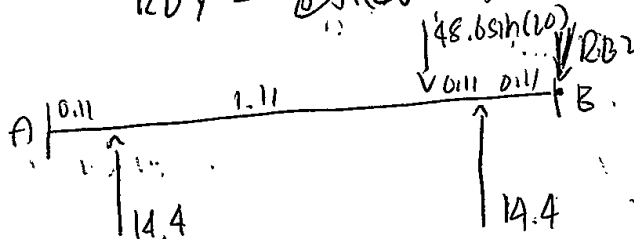
$$R_{BV} (1.44) + (48.6 \cos(20)) (1.22) = 122 \times 0.11 + (122 \times 1.33)$$

$$R_{BV} = 122.000$$

$$(R_{BV} \times 1.44) + (48.6 \cos(20)) \times 1.22 = (122 \times 0.11) + (122 \times 1.33)$$

$$1.44 R_{BV} = 119.9637451$$

$$R_{BV} = 83.3 \text{ kN}$$



moments about A

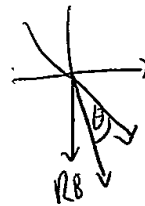
$$\sum CW M = \sum ACW M$$

$$(R_{B2} \times 1.44) + (48.6 \sin(20)) \times 1.22 = (14.4 \times 0.11) + (14.4 \times 1.23)$$

$$1.44 R_{B2} = 6.436 \dots$$

$$R_{B2} = 0.3 \text{ kN} \quad \theta = \tan^{-1} \left( \frac{83.3}{0.3} \right)$$

$$R_B = \sqrt{0.3^2 + 83.3^2} = 83.3 \text{ kN at } 89.8^\circ \text{ from horizontal (down and right)}$$



ENTER  
NUMBER  
OF  
QUESTION

9) a) moments about  $R_B$   
 $E I_{cm} = E A l_{cm}$

$$(R_A \times 6) = (750 \times 3) + (25 \times 4) + (50 \times 2)$$

$$6 R_A = 2450$$

$$R_A = 410 \text{ kN}$$

$$E \uparrow F = E \downarrow F$$

$$R_A + R_B = 750 + 75$$

$$\cancel{410 + R_B} = 825 \quad R_B = 415 \text{ kN}$$

b) i)  $M = 410(x-2) - \frac{75x^2}{2} - 25(x-4)$

$$M = 410x - 820 - \frac{75}{2}x^2 - 25x + 100$$

$$M = 385x - \frac{75}{2}x^2 - 720$$

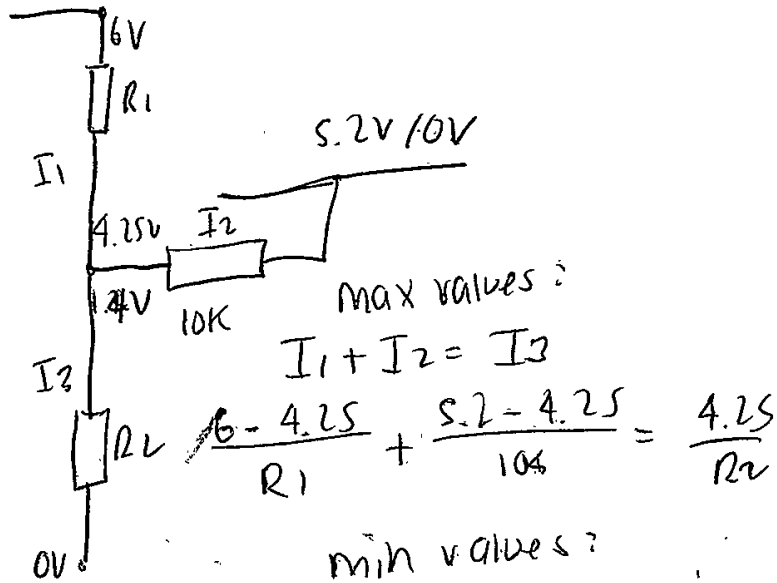
ii) ii)  $\frac{dM}{dx} = 385 - 75x = 0$  at max/min

$$75x = 385$$

$$x = 5.1 \text{ m (2sf)}$$

ENTER  
NUMBER  
OF  
QUESTION

9(c)



$$\frac{6 - 1.4}{R_1} + \frac{0 - 1.4}{10} = \frac{1.4}{R_2}$$

x top by 1.4

$$\frac{2.45}{R_1} + 0.133 = \frac{5.95}{R_2}$$

x bottom by 4.25

$$\frac{19.55}{R_1} - 0.595 = \frac{5.95}{R_2}$$

$$\frac{19.55}{R_1} - 0.595 = \frac{2.45}{R_1} + 0.133$$

ENTER  
NUMBER  
OF  
QUESTION

9)c)

$$19.55 - 0.595R_1 = 2.45 + 0.133R_1$$

~~$$19.55 \Rightarrow 17.1 = 0.728R_1$$~~

$$R_1 = 23.5 \text{ k}\Omega \text{ (3sf)}$$

~~$$R_2 \Rightarrow \frac{2.45}{R_1} + 0.133 = \frac{5.95}{R_2}$$~~

$$\frac{2.45}{23.5} + 0.133 = \frac{5.95}{R_2}$$

$$\frac{5.95}{R_2} = 0.2372553191$$

$$R_2 = 25 \text{ k}\Omega \text{ (2sf)}$$

d)

10 revs min<sup>-1</sup> means 10x up or down  
but there could've been a diff

~~$$\frac{10 \times 100}{100} = 100\%$$~~
~~$$\frac{10 \times 100}{100} = 10\%$$~~
~~$$\frac{10 \times 100}{100} = 10\%$$~~

e)

include a calculation in the program  
that multiplies the speed by 0.05

\* IF speed > 5 revs min<sup>-1</sup>

Let a variable  $x$  be speed,  $y$  be the maximum speed  
( $x + (x \times 0.05)$ ), ( $x - (x \times 0.05)$ )

ENTER  
NUMBER  
OF  
QUESTION

9)e)

If

$$y_1 = (x + (x \times 0.05))$$

$$y_2 = (x + (x \times 0.05))$$

$$x = 9$$

$$x = 5$$

$$\begin{aligned} \text{so } y_1 &= \text{max} \\ y_2 &= \text{min} \end{aligned}$$

enter a command such as :

IF  $y_1 < x < y_2$  THEN display  
speed

ELSE

display error message

$$\left( \begin{array}{l} \text{so } y_1 = 9.45 \\ y_2 = 4.75 \end{array} \right)$$
 for max/min  
 values being  
 $x = 5, x = 9$

ENTER  
NUMBER  
OF  
QUESTION

(6)9

$$\begin{aligned} \Delta V_{OUT} &= \frac{1}{nC} \int -q \, dt \\ &= \frac{1}{9100 \times 100 \times 10^{-9}} \int -9t \, dt \\ &= \frac{1}{9100} \times \frac{-9t^2}{2} \\ &= -9900t \end{aligned}$$

$$-q = VB$$

~~Question~~ was unclear whether to use old or new C value

$$\begin{aligned} V_2 &= \frac{1}{nL} \int V_{in} \, dt \\ &= \frac{1}{5600 \times 23 \times 10^{-4}} \int 5t \, dt \\ &= -27t \end{aligned}$$

$$\begin{aligned} \Delta V_{OUT} &= \frac{1}{nC} \int -27t \, dt \\ &= \frac{1}{9100 \times 100 \times 10^{-9}} \int \frac{-27t^2}{2} \, dt \\ &= 1100 \times \frac{-27}{2} t^2 \end{aligned}$$

$$\begin{aligned} \Delta V_{OUT} &= 150 \times 10^3 t^2 \\ &= 1.5 \times 10^4 t^2 \text{ (2sf)} \end{aligned}$$

# Candidate 4 evidence

Worksheet for question 3 (b)

Stage	Precedents	Duration
A	----	4
B	----	1
C	B	4
D	A, B	7
E	C	3
F	E	6
G	A, C	7
H	D, F, G	3

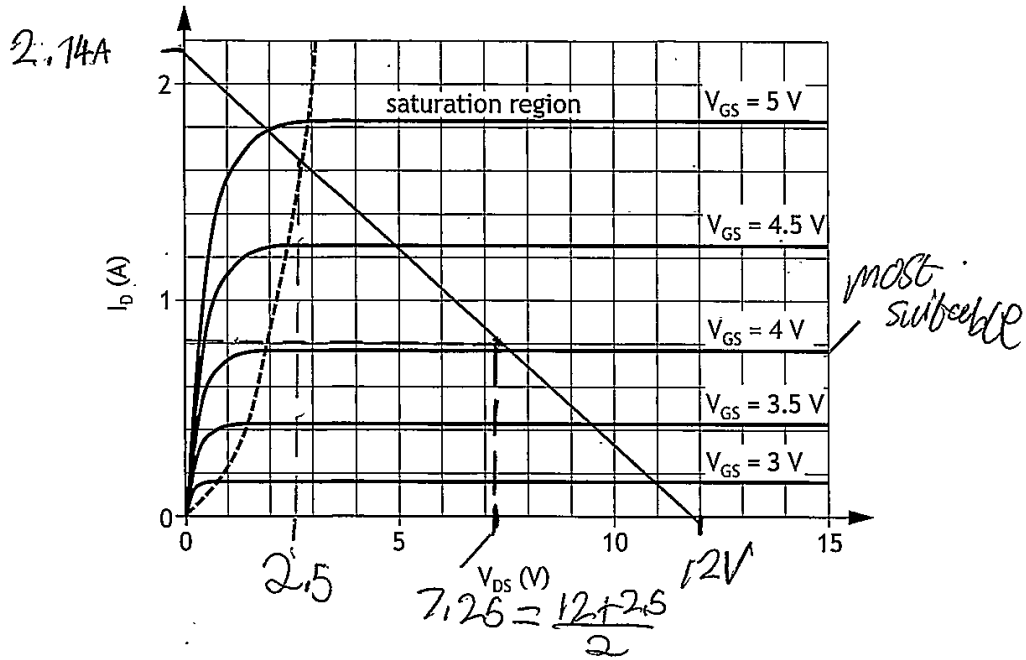
(i)

	Week																
Stage	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
A					F	F	F										
B																	
C																	
D												F	F	F			
E																	
F																	
G					<del>    </del>	<del>    </del>	<del>    </del>	<del>    </del>	<del>    </del>	<del>    </del>	<del>    </del>	<del>    </del>	<del>    </del>	<del>    </del>	<del>    </del>	<del>    </del>	<del>    </del>
H																<del>    </del>	<del>    </del>

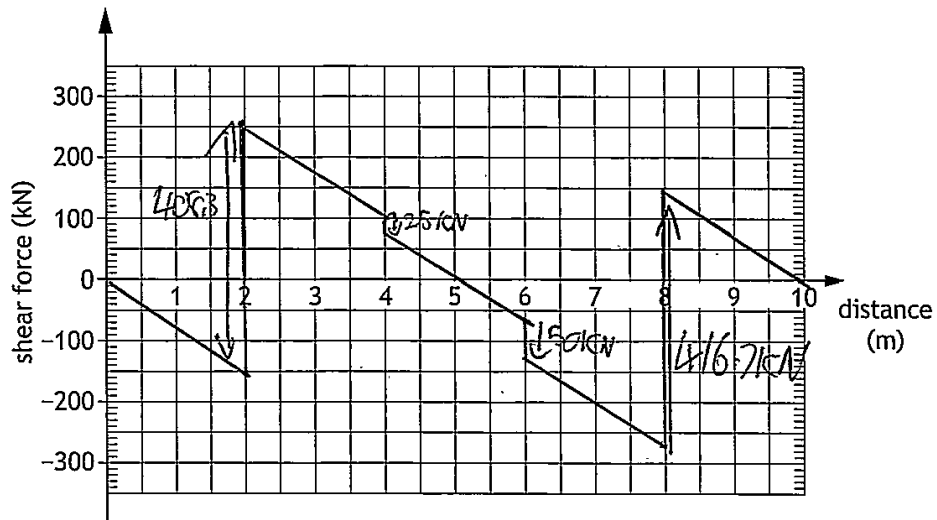
Scribbles are blank spaces

(ii) Critical path BCEFH

Worksheet for question 4 (a)



Worksheet for question 9 (a)



ENTER  
NUMBER  
OF  
QUESTION

①

$$I_{\frac{1}{2}} = I_{\text{rect}} - 2 \times I_{\text{tri}}$$

$$= \frac{BD^3}{12} - 2 \left( \frac{bh^3}{12} \right)$$

$$= \frac{15 \times 40^3}{12} - 2 \left( \frac{10 \times 10^3}{12} \right)$$

$$= 958.33 \dots \times 10^3$$

$$= 958.3 \times 10^3 \text{ mm}^4$$

$$I_T = 2 \times I_{\frac{1}{2}}$$

$$= 2 \times 958.33 \dots \times 10^3$$

$$= 1.9166 \dots \times 10^6$$

$$= 1.92 \times 10^6 \text{ mm}^4 \text{ (358)}$$

ENTER  
NUMBER  
OF  
QUESTION

2a) Hydro electric pump storage systems store a sum of water to be used for hydroelectric purposes on demand. This is important as it means during times of high demand there is an immediate way to meet it safely as nuclear can't be turned up and down quickly.

$$b) 0.96 \times 1 \times 0.97 \times 0.97 \times 0.94$$

$$= 0.849061112$$

$$= 0.85 \text{ units per unit produced}$$

MP10r

ENTER  
NUMBER  
OF  
QUESTION

3c) Capital costs are the cost of running a project for the result. One reason there may be a predicted downward trend in costs is from making improvements to the efficiency of the turbines or finding cheaper alternative suppliers of materials. These would then either improve efficiency which lowers capital cost per MW or make it outright cheaper to build and thus lower capital cost per MW.

ENTER  
NUMBER  
OF  
QUESTION

30) The project manager could ensure the critical path's always on track and if it lags behind, divert man hours and resources away from projects with float time to correct.

$$4b) \frac{R_1 R_2}{R_1 + R_2} = 100 \times 10^3 \quad \frac{R_1}{R_2} = \frac{V_S - V_{GS}}{I_D}$$

$$= \frac{12 - 4}{0.8}$$

~~$R_1 = 10R_2$~~

$$\frac{R_2 \times 10R_2}{11R_2} = 100 \times 10^3$$

$$\frac{R_1}{R_2} = 10$$

$$R_1 = 10R_2$$

$$\frac{10R_2}{11} = 100 \times 10^3$$

$$R_2 = \frac{11 \times 100 \times 10^3}{10}$$

$$= 110 \times 10^3 \Omega$$

$$R_1 = 10R_2 = 10 \times 110 \times 10^3$$

$$= 1.1 \times 10^6 \Omega$$

ENTER  
NUMBER  
OF  
QUESTION

$$5) E_{\text{switching}} = \frac{1}{2} V_{\text{DSS}} (T_{\text{on}} I_{\text{DSS}} + T_{\text{off}} I_{\text{DSS}})$$

$$= \frac{1}{2} \times 12 (24 \times 10^9 \times 3 + 28 \times 10^9 \times 3)$$

$$= 436 \times 10^9$$

$$T_{\text{on}} T_{\text{off}} = 52 \times 10^{-9} \text{ s}$$

$$\frac{1}{52 \times 10^{-9}} = 8$$

$$P_{\text{switching}} = E_{\text{switching}} \times 8$$

$$8 = 14.23 \times 10^6$$

$$= 14.23 \times 10^6$$

$$= 436 \times 10^9 \times 14.23 \times 10^6$$

$$= 17.997 \dots$$

$$= 18 \text{ W (358)}$$

$$6) V_2 = -\frac{1}{5600} \times 5 \text{ Vindt}$$

$$-9 = -\frac{1}{5600} \times 5 \times 0.2$$

$$C = \frac{1}{9 \times 5600} \times 5 \times 0.2$$

$$= 19.84 \dots \times 10^{-6}$$

$$= 19.8 \times 10^{-6} \text{ F (358)}$$

ENTER  
NUMBER  
OF  
QUESTION

6b) The time taken increases as

$$V_{out} = \frac{-1}{RC} \times V_{int} \quad \text{increasing } C, \text{ longer time}$$

$$6c) \quad V_2 = \frac{1}{5.6 \times 10^3 \times 33 \times 10^{-6}} \times \int V_{int} dt$$

$$V_2 = - \frac{56}{5.6 \times 10^3 \times 33 \times 10^{-6}}$$

$$V_{out} = - \frac{1}{RC} \int V_2 dt$$

$$= - \frac{1}{4100 \times 100 \times 10^{-6}} \times - \frac{1}{5600 \times 33 \times 10^{-6}} \int 56 dt$$

$$= 5.946 \text{ m} \int 56 dt$$

$$= 29.732 \text{ m} \times \frac{t^2}{2} + C$$

$$= 14.866 \text{ m} \times t^2 + C$$

$$= \underline{14.96^2 (358) + C}$$

ENTER  
NUMBER  
OF  
QUESTION

$$7a) I = 21 \times 10^3 \quad L = 1.5 \text{ m} \times 10^3$$

$$P = \frac{140}{2} = 70 \quad E = 200 \times 10^3$$

$$a = 0.50 \times 10^3$$

$$\delta = \frac{Pa}{24EI} (3L^2 - 4a^2)$$

$$= \frac{70 \times 0.50 \times 10^3}{24 \times 200 \times 10^3 \times 21 \times 10^3} \times (3 \times 1.5^2 - 4 \times 0.5^2)$$

$$(3 \times (1.5 \times 10^3)^2 - 4 \times (0.5 \times 10^3)^2)$$

$$= 2.707111$$

$$= 2.71 \text{ mm (3sf)}$$

MA

$$7b) \frac{M}{I} = \frac{\sigma}{y}$$

$$\frac{Pa}{21 \times 10^3} = \frac{\sigma}{\left(\frac{21}{2}\right)}$$

$$\sigma = \frac{-70 \times 0.5 \times 10^3 \times \left(\frac{21}{2}\right)}{21 \times 10^3}$$

$$\sigma = -32.776111$$

$$= -32.8 \text{ Nmm}^{-2}$$

ENTER  
NUMBER  
OF  
QUESTION

7) The weight is safe no matter what  
as G60 at a minimum is a FOS of  
20.7

8a) A - Converter a converter is  
B - Driver required to convert  
the ac current into DC, and  
~~the drivers~~

$$b) 5.2 \text{ MW} = P \quad P_{\text{loss}} = 2.5 \times 10^3$$

$$V_1 = 25 \times 10^3 \quad V_2 = 1.5 \times 10^3$$

$$R_1 = 482 \times 10^{-3} \quad R_2 = 1.24 \times 10^{-3}$$

$$P = VI$$

$$I = \frac{5.2 \times 10^6}{25 \times 10^3}$$

$$= 208 \text{ A}$$

$$P_{\text{loss}} = I^2 R + 2.5 \times 10^3$$

$$= 208^2 \times 1.24 \times 10^{-3} + 2.5 \times 10^3$$

$$= 2600.256$$

$$= 2600 \text{ W}$$

$$= 2.6 \times 10^3 \text{ W}$$

ENTER  
NUMBER  
OF  
QUESTION

$$P_{\text{loss}} = 2.6 \times 10^3$$

$$P_{\text{out}} = 5.2 \times 10^6 - 2.6 \times 10^3 = 23.35 \times 10^3$$

$$\Rightarrow \cancel{5.174 \times 10^6} \text{ W} \quad 5.176 \times 10^6 \text{ W}$$

$$P_{\text{out}} = V_2 I_2$$

$$I_2 = \frac{P_{\text{out}}}{V_2} = \frac{\cancel{5.174 \times 10^6} \cdot 5.176 \times 10^6}{1.5 \times 10^3}$$

$$= \cancel{3464.93} \text{ A} = 3460.66 \text{ A}$$

$$= \cancel{3465} \text{ A} = \underline{\underline{3450 \text{ A}}}$$

$$P_{\text{loss}_2} = I^2 R$$

$$= \cancel{3465^2} \cdot 3451^2 \times 1.74 \times 10^{-3}$$

$$= 20.722 \text{ A} \times 10^{-3}$$

$$= 20.7 \times 10^{-3} \text{ W (358)}$$

↑

resistive power loss in secondary winding

ENTER  
NUMBER  
OF  
QUESTION

8c) The period in total can be varied by increasing or decreasing the duty microseconds command. This would increase <sup>or decrease</sup> the time per cycle and thus increase ~~or decrease~~ the total period.

8d) Calculating the duty values within each loop would give a more accurate waveform as the numbers for duty would be more accurate to the PWM signal which would mean a higher resolution. This would result in a more accurate waveform than using predetermined block values, as they are less accurate.

ENTER  
NUMBER  
OF  
QUESTION

$$d_1 = 480 \text{ mm}$$

$$\alpha = 20^\circ$$

$$P = 80 \times 10^3$$

$$n = \frac{1800}{60} = 30 \text{ rev/s}$$

$$\frac{\text{PCD}}{\text{teeth}} = Z \quad \frac{480}{60} = 8$$

$$8 = \frac{\text{PCD}_2}{50} \quad \text{PCD}_3 = 8 \times 45 = 360 \text{ mm}$$

$$\text{PCD}_2 = 400 \text{ mm}$$

$$P = 2\pi r \omega$$

$$T = 2\pi r \times 30$$

$$T = \frac{80 \times 10^3}{2\pi \times 30} = 424.4 \text{ Nm}$$

ENTER  
NUMBER  
OF  
QUESTION

$$T = Fr$$

$$42414 = F_r \times \frac{480}{2}$$

$$\frac{42414}{\frac{480}{2}} = F_r \cos 20$$

$$1.7683 \dots = F_r \cos 20$$

$$F = \frac{1.7683}{\cos 20}$$

$$= 1.8818 \dots$$

$$= 1.882 \text{ N}$$

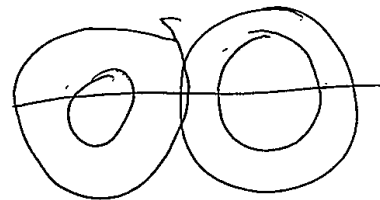
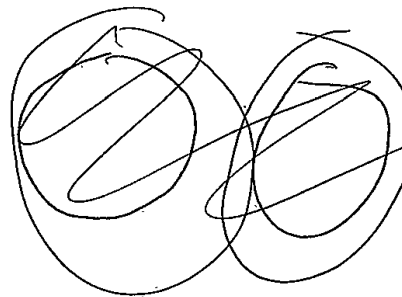
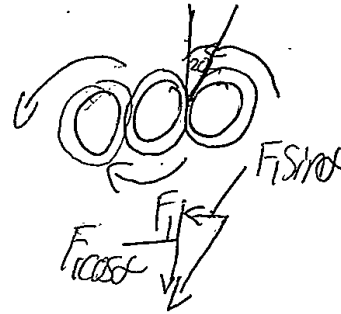
$$T = Fr$$

$$T_2 = \frac{1.882 \text{ N} \times 400}{2}$$

$$T_2 = \frac{353.66}{2} = 376.4 \text{ Nmm}$$

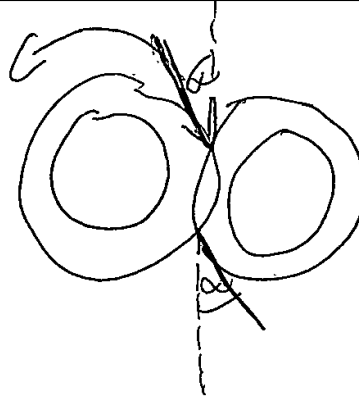
$$T_3 = \frac{80 \times 10^3}{2\pi \times 36 \times \frac{400}{360}}$$

$$= 318.3 \dots = 318.3 \text{ Nmm}$$



ENTER  
NUMBER  
OF  
QUESTION

$$T_3 = 318.3N$$



$$F_T r = 318.3$$

$$F_T = \frac{318.3}{180}$$

$$= 1.7683...$$

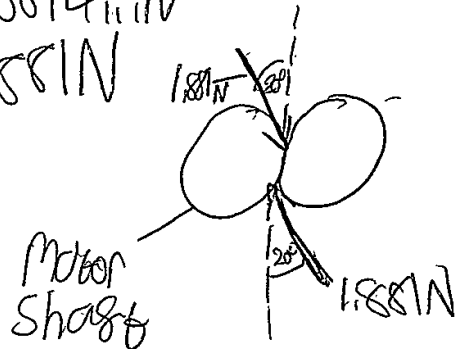
$$= 1.768N$$

$$= 1.768N$$

$$F = \frac{\cancel{\cos 20} 1.768}{\cos 20}$$

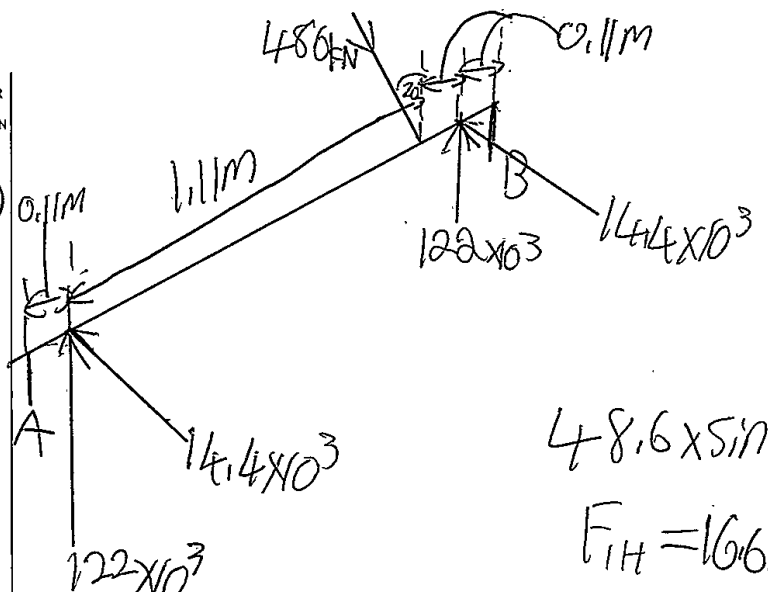
$$= 1.8814...N$$

$$= 1.881N$$



ENTER NUMBER OF QUESTION

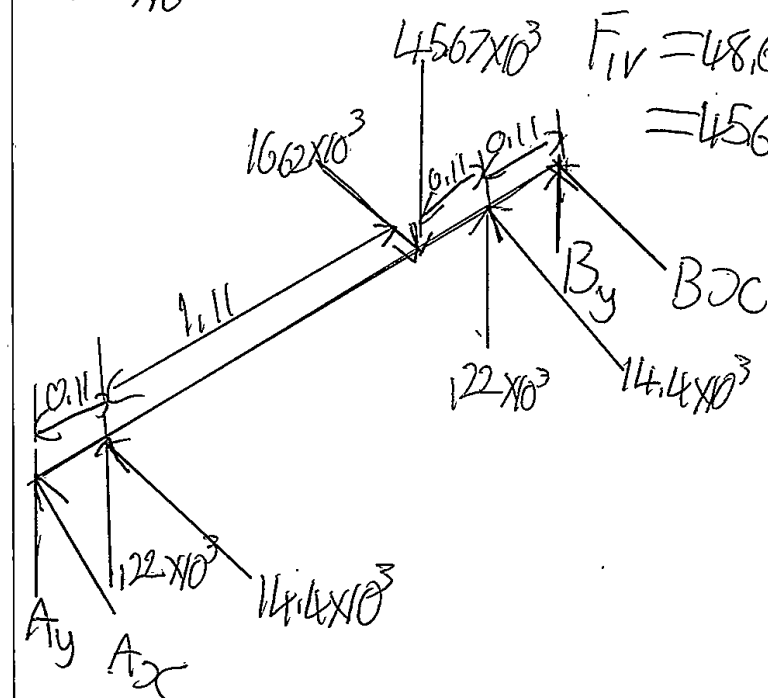
85



$$48.6 \times \sin 20 = F_{IH}$$

$$F_{IH} = 16.62 \times 10^3 \text{ N}$$

$$F_{IV} = 48.6 \times 10^3 \times \cos 20 = 45.67 \times 10^3 \text{ N}$$



Reactions from A  $F_c$

$$0 = 0.11 \times 14.4 \times 10^3 - 1.22 \times 16.62 \times 10^3 + 1.33 \times 14.4 \times 10^3 + 14.4 \times B_c$$

$$14.4 B_c = -457.6$$

$$B_c = -31.776 \dots = 31.2 \text{ N (ve so } \downarrow)$$

ENTER  
NUMBER  
OF  
QUESTION

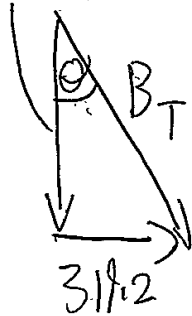
$$R_{Ay} = 0$$

$$0 = 0.11 \times 22 - 1.22 \times 45.67 + 1.33 \times 22 + 1.144 B_y$$

$$\begin{aligned} 1.144 B_y &= 1.22 \times 45.67 \times 10^3 - 0.11 \times 22 \times 10^3 - 1.33 \times 22 \times 10^3 \\ &= -117.9626 \times 10^3 \end{aligned}$$

$$B_y = -83.31 \times 10^3 \text{ N (ve so } \downarrow)$$

$$83.31 \times 10^3$$



$$B_T = \sqrt{83.31 \times 10^3^2 + 317.2^2}$$

$$= 8330.61511$$

$$= 83.31 \times 10^3 \text{ N } \theta = 0.2^\circ$$

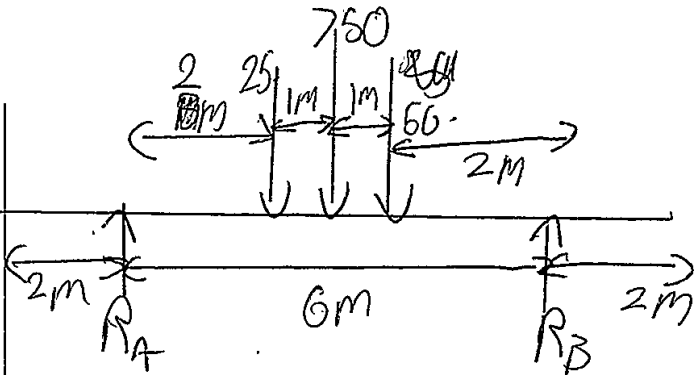
$$\tan^{-1}\left(\frac{317.2}{83.31 \times 10^3}\right) = \theta$$

$$\theta = 0.29511$$

$$= 0.2^\circ$$

ENTER NUMBER OF QUESTION

9a)



$$F_{udl} = 75 \times 10$$

$$= 750 \text{ kN}$$

$$6R_B = 2 \times 25 + 3 \times 750 + 4 \times 50$$

$$= 2500$$

$$R_B = 416.66 \dots$$

$$= 416.7 \text{ kN}$$

$$R_A = F_T - R_B$$

$$= 825 - 416.7$$

$$= 408.3 \text{ kN}$$

9b)i

$$M_B = 408.3(2x-2) - 25(x-4) - 75x\left(\frac{x}{2}\right)$$

$$= 408.3x - 816.6 - 25x + 100 - \frac{75x^2}{2}$$

$$= -\frac{75x^2}{2} + 383.3x - 716.6$$

$$\frac{-b \pm \sqrt{b^2 - 4ac}}{2a} = \frac{383.3 \pm \sqrt{383.3^2 - 4 \times \frac{75}{2} \times (-716.6)}}{75}$$

$$\frac{-\frac{75}{2} \pm \sqrt{\frac{75^2}{4} + 4 \times 383.3 \times 716.6}}{75} = 1.6145 \dots$$

ENTER NUMBER OF QUESTION

bii) 
$$\frac{d}{dx} \left( \frac{-750x^2}{2} + 383.3x - 716.6 \right)$$

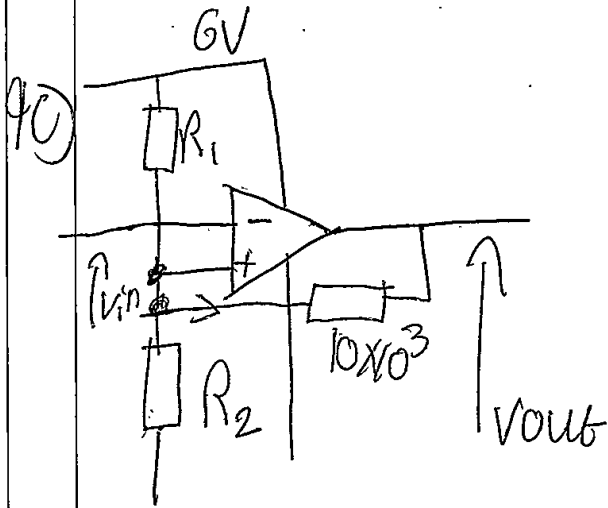
$$= -750x + 383.3 = 0$$

$$\Rightarrow 750x = 383.3$$

$$x = \frac{383.3}{75}$$

$$= 5.110660 \text{ u.s.}$$

$$= \underline{5.11 \text{ mcs}}$$



ENTER  
NUMBER  
OF  
QUESTION

$$I_1 - I_2 - I_3 = 0$$

$$\frac{6 - V_A}{R_1} - \frac{V_A}{R_2} - \frac{V_A - 5.2}{10} = 0$$

$$\frac{6}{R_1} + \frac{5.2}{10} = \frac{V_A}{10} + \frac{V_A}{R_1} + \frac{V_A}{R_2}$$

$$\frac{60}{R_1} + 5.2 = V_A + \frac{10V_A}{R_1} + \frac{10V_A}{R_2}$$

$$\frac{60}{R_1} + 5.2 = 4.25 + \frac{42.5}{R_1} + \frac{42.5}{R_2}$$

$$\frac{60 - 42.5}{R_1} = \frac{0.95}{4.5} + \frac{42.5}{R_2}$$

$$\frac{6 - \frac{1.40}{5}}{R_1} - \frac{1.40}{R_2} - \frac{1.40}{10} = 0$$

$$\frac{4.6}{R_1} = 1.4 + \frac{14}{R_2}$$

ENTER  
NUMBER  
OF  
QUESTION

$$\frac{17.5}{R_1} = \frac{-9.5 + 42.5}{R_2} \times 46$$

$$\frac{46}{R_1} = 1.4 + \frac{14}{R_2} \times 17.5$$

$$\frac{805}{R_1} = 24.5 + \frac{1955}{R_2}$$

$$\frac{805}{R_1} = 24.5 + \frac{245}{R_2}$$

$$0 = \frac{461.5}{R_1} + \frac{2200}{R_2}$$

$$\frac{2200}{R_2} = 461.5$$

$$R_2 = \frac{461.5}{2200} \times 10^3$$

$$= 209.7 \text{ m}$$

$$= \underline{\underline{210 \Omega}}$$

ENTER  
NUMBER  
OF  
QUESTION~~R1 = 17.5~~

$$\frac{17.5}{R_1} = 7.5 + \frac{42.5}{210}$$

$$\frac{17.5}{R_1} = 172.88 \dots$$

$$R_1 = \frac{17.5}{172.88} \times 10^3$$

$$= 40.72 \dots$$

$$= \underline{40.7 \Omega}$$

ENTER  
NUMBER  
OF  
QUESTION

9d) ~~1/2~~  $\frac{3}{2} = 50\% \text{ error}$

$$\frac{n}{n-1} = \%$$

$$\frac{10}{9} = \% \text{ error}$$

$$10 = \frac{10}{9} = 11.111\% \text{ error}$$

$$\frac{10}{9} = 11.1\% \text{ error}$$

= 10% error for  
Output speed 10

9e) for one, the values would  
have to be floats instead  
of integers for the use  
of decimal points.

ENTER  
NUMBER  
OF  
QUESTION

and the use of PPM counter  
would need to be adapted  
as ~~this is only good~~ is currently  
only works for integers,  
perhaps if the program was  
upscaled so it checked over  
more than 35, then an  
accurate reading could then  
be made by incrementing  
with smaller decimal  
values.