

ENGINEERING SCIENCE 2

COURSEWORK

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Motorcycle Engineering (BEng)
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1 Question 1

Q1

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Engineering Science 2 Coursework

a) $V = 12V$

$r = 6\Omega$

$R = 10\Omega$

$\frac{V}{R} = I = \frac{12}{10} = 1.2 \text{ (Amps)}$

$P = IV = 1.2 \times 12 = \underline{\underline{14.4 \text{ (Watts)}}}$

b)

$r = 6\Omega$

$R = 10\Omega$

$V = 12V$

Calculating $\mathcal{E}$

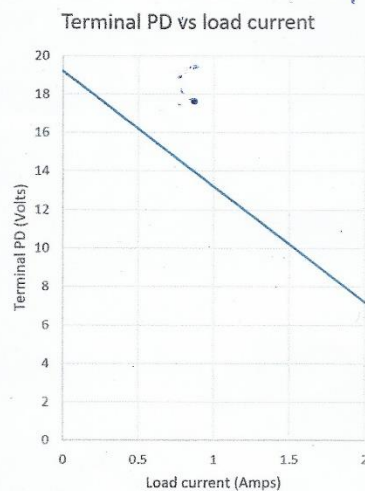
$\mathcal{E} = Ir + V$

$\mathcal{E} = 1.2 \times 6 + 12$

$\mathcal{E} = 19.2V$

Graph generated using $V = \mathcal{E} - Ir$

Current	Terminal PD
0	19.2
0.1	18.6
0.2	18
0.3	17.4
0.4	16.8
0.5	16.2
0.6	15.6
0.7	15
0.8	14.4
0.9	13.8
1	13.2
1.1	12.6
1.2	12
1.3	11.4
1.4	10.8
1.5	10.2
1.6	9.6
1.7	9
1.8	8.4
1.9	7.8
2	7.2



• Shows voltage decrease at terminals as load current increases.

This is due to the lost volts (Ir) increasing with the increase in current, (due to the internal resistance of the battery)

Identify the load

c)

Current/A	V=EMF-Ir Terminal PD/V	R=V/I load resistance/Ohm	P=IV Power/W
0.00	19.20	NA	0
0.10	18.60	186.00	1.86
0.20	18.00	90.00	3.6
0.30	17.40	58.00	5.22
0.40	16.80	42.00	6.72
0.50	16.20	32.40	8.1
0.60	15.60	26.00	9.36
0.70	15.00	21.43	10.5
0.80	14.40	18.00	11.52
0.90	13.80	15.33	12.42
1.00	13.20	13.20	13.2
1.10	12.60	11.45	13.86
1.20	12.00	10.00	14.4
1.30	11.40	8.77	14.82
1.40	10.80	7.71	15.12
1.50	10.20	6.80	15.3
1.60	9.60	6.00	15.36
1.70	9.00	5.29	15.3
1.80	8.40	4.67	15.12
1.90	7.80	4.11	14.82
2.00	7.20	3.60	14.4

With

The battery can deliver maximum Power (~15.36 W) at with the a load resistance of ~6 Ω

OBSERVATION:

The Maximum power can be achieved when the load resistance is the same as the internal resistance

(i) $R = 100 \Omega$ (@ $0^\circ C$)
 $P = 9.81 \times 10^{-8}$ (@ $0^\circ C$)
 $\phi = 0.050 \text{ mm}$

$$L = 100 \times \frac{\pi \times (0.050 \times 10^{-3})^2}{4 \times 9.81 \times 10^{-8}}$$

$$L = 2.00 \text{ m}$$

(ii) ~~for~~

$$\frac{\pi \phi^2}{4} \times L = \text{volume}$$

$$\frac{\pi \times (0.050 \times 10^{-3})^2}{4} \times 2 = 3.93 \times 10^{-9} \text{ m}^3$$

(iii) Density = $\frac{\text{Mass}}{\text{Volume}}$

Density $\times$ volume = mass
 $(21.45 \times 10^3) \times (3.93 \times 10^{-9}) = 8.43 \text{ kg} \times 10^{-5} \text{ kg}$

Price per kg $\times$ Mass = final cost
 $10000 \times (8.43 \times 10^{-5}) = \underline{\underline{\pounds 0.84}}$

(iv) $R = 100 \Omega$
 (v) $\text{base} = 4.0 \times 10^{-4} \text{ cm}$
 $L = 81 \text{ cm}$

$$\rho = \frac{RA}{L}$$

$$\rho = \frac{R(b \times h)}{L}$$

$$\frac{\rho L}{Rb} = h$$

$$\frac{(9.81 \times 10^{-8}) \times (81 \times 10^{-2})}{100 \times ((4 \times 10^{-4}) \times 10^{-2})} = \underline{\underline{1.99 \times 10^{-4} \text{ m}}}$$

(vi) $\text{Volume} = \text{base} \times \text{height} \times \text{thickness}$ ~~length~~ $\times \text{thickness}$

$$6.45 \times 10^{-10} \text{ m}^3 = ((4 \times 10^{-4}) \times 10^{-2}) \times (81 \times 10^{-2}) \times 1.99 \times 10^{-4}$$

$$\text{Density} \times \text{Volume} = \text{mass}$$

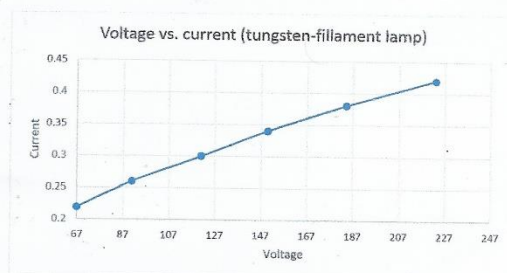
~~$$(9.81 \times 10^{-8}) \times (1.99 \times 10^{-4}) =$$~~

~~$$(9.81 \times 10^{-8})$$~~

$$(21.45 \times 10^3) \times (6.45 \times 10^{-10}) = 1.38 \times 10^{-5} \text{ kg}$$

$$\text{Price per kg} \times \text{mass} = \text{final cost}$$

$$10\,000 \times (1.38 \times 10^{-5}) = \underline{\underline{\pounds 0.14}}$$



- A tungsten fillament lamp does not obey the ohm's law.
- The gradient of Current vs. Voltage graph represents the resistance ($y = mx + c$)
- The gradient ~~gets~~ ^{becomes} flatter the higher the voltage
- This indicates an increase in resistance when voltage is increased
- This is due to the increase in heat, which causes an increase in resistance

2 Question 2

Q2) a)(i) $W = \frac{1}{2} QV$

$V = 8 \text{ kV}$
 $Q = 10 \mu\text{C}$

$$W = \frac{1}{2} \times (10 \times 10^{-6}) \times (8 \times 10^3) = \underline{0.04 \text{ J}}$$

(ii) $C = 10 \mu\text{F}$
 $I = 200 \mu\text{A}$
 $T = ?$
 $V = 2000 \text{ V}$
 $V_0 = 0 \text{ V}$

$$Q = It \rightarrow \frac{Q}{I} = t$$

~~$$\frac{Q}{I} = \frac{CV}{I}$$~~

sub/merge:

~~$$\frac{I t}{I} = \frac{CV}{I}$$~~

$$\frac{CV}{I} = t$$

$$t = \frac{(10 \times 10^{-6}) \times 2000}{(200 \times 10^{-6})} = \underline{100 \text{ seconds}}$$

b) capacitance ratio:

$$\frac{C_x}{C_y} = \frac{1000}{100} = 10$$

Voltage is constant

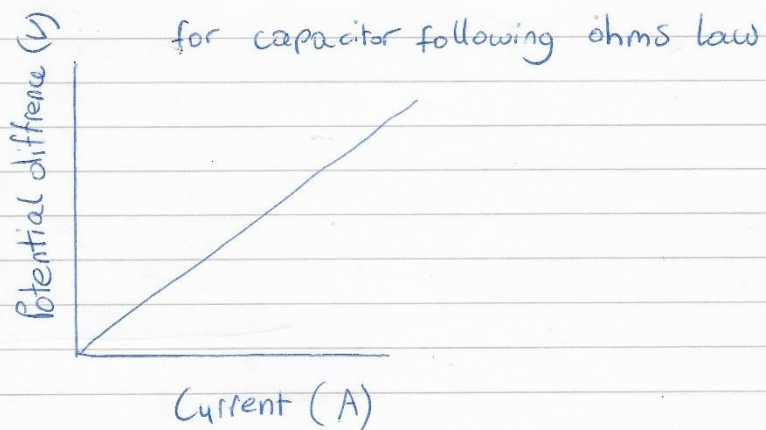
$$Q = C(V) - \text{constant}$$

$$W = \frac{1}{2} C(V^2) - \text{constant}$$

thus charge and ~~capacitance~~ ^{Energy} ratio are the same as capacitance ratio.

~~Table~~ Row D contains the correct ratios

c)
(i)



(ii) and (iii)

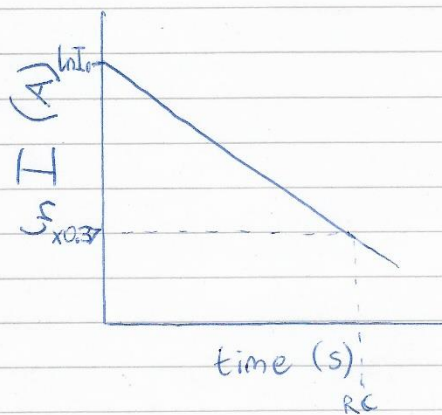
$$\ln I = a + bt$$

$\uparrow$ $\uparrow$ $\uparrow \uparrow$
 y c $m x$

therefore:

$$\ln I = \ln I_0 - \frac{t}{RC}$$

(iv)



3 Question 3

Q3)
(a)

known values:

$$V_1 = 0.52 \text{ m}^3$$

$$P_1 = \cancel{10 \text{ bar}} (1.5 \times 10^5 \text{ N/m}^2)$$

$$T_1 = 85^\circ\text{C} ($$

$$V_2 = 0.2 \text{ m}^3$$

$$P_2 = \cancel{5 \times 10^5} 5 \text{ bar} (5 \times 10^5 \text{ N/m}^2)$$

Gas constant (R) of oxygen: 0.2598 kJ/kgK
(259.8 J/kgK)

Working out mass:

$$PV = mRT$$

$$\frac{PV}{RT} = m = \frac{(1.5 \times 10^5) \times (0.52)}{(259.8) \times (358)}$$

$$\underline{m = 0.84 \text{ kg}}$$

(knowing that
 $v = \frac{V}{m}$)

($PV = mRT$ chosen
as its easier to
work with than
 $\frac{PV}{m} = RT$)

b) $P_1 V_1^n = P_2 V_2^n$

corrected

bringing
powers
down using logs

$$\frac{V_1^n}{V_2^n} = \frac{P_2}{P_1}$$

$$n \log \left(\frac{V_1}{V_2} \right) = \log \left(\frac{P_2}{P_1} \right)$$

$$n = \frac{\log \left(\frac{P_2}{P_1} \right)}{\log \left(\frac{V_1}{V_2} \right)}$$

$$1.26 = \frac{\log \left(\frac{(5 \times 10^5)}{(1.5 \times 10^5)} \right)}{\log \left(\frac{0.52}{0.2} \right)}$$

$$n = 1.26$$

there fore

~~$$n < k (259.8)$$~~

~~$$n > 1$$~~

~~thus the process must be isometric~~

- ~~n is not equal to 0~~
- ~~n is not equal to 1~~
- ~~n is not equal to $k (259.8)$~~
- ~~Thus the process is isometric~~

• n is not ∞

• Thus $n = k$ (process is isentropic)

(c) Working out T_2

$$m_1 = m_2$$

$$PV = mRT$$

$$\frac{P_2 V_2}{mR} = T_2$$

$$\frac{(5 \times 10^5) \times (0.2)}{(0.84) \times (259.8)} = 458.23$$

$$T_2 = 458.23 \text{ K}$$

$$\Delta H = \Delta U + \Delta P \Delta V$$

$$\Delta U = \Delta H - \Delta P \Delta V$$

$$(77.29 \times 10^3) - ((5 \times 10^5) - (1.5 \times 10^5)) \times (0.2 - 0.52)$$

$$\Delta U = 189290 \text{ J}$$

$$\Delta h = c_p (\Delta T)$$

$$19.8 = 0.918 (458.23 - 358)$$

$$\Delta h = 92.01 \text{ kJ/kg}$$

$$\Delta h \times m = \Delta H$$

$$92.01 \times 0.84 = 77.29$$

$$\Delta H = 77.29 \text{ kJ}$$

$$(77.29 \times 10^3 \text{ J})$$

$$(d) \Delta U = Q - W$$

$$\Delta U + W = Q$$

$$189290 - 84615.38 = 104674.62$$

$$Q = 104674.62 \text{ J}$$



heat received during compression

working out work (W_b):

$$W_b = \int_1^2 P dV = \frac{P_2 V_2 - P_1 V_1}{1 - n}$$

∴

$$= \frac{(5 \times 10^5) \times (0.2) - (1.5 \times 10^5) \times (0.52)}{1 - 1.26}$$

$$W_b = -84615.38$$

4 Question 4

Q4) $P_1 = 10 \times 10^5 \text{ Pa (10 bar)}$
 $T_1 = 200^\circ \text{C (473 K)}$
 medium₁ = Superheated water
 $T_3 = 50^\circ \text{C (323 K)}$
 $x_3 = 0.2$

$P_2 = P_1$
 medium₂ = Sat. Liquid water
 $T_4 = T_2 - 10^\circ \text{C (} T_2 - 283 \text{ K)}$
 $x_4 = 0.23$
 $\dot{m}_4 = 3 \times 10^5 \text{ g/min}$
 $(3 \times 10^2 \text{ kg/min})$
 $(\frac{3 \times 10^2}{60} \text{ kg/s}) \quad (5 \text{ kg/s})$

part a)

a) if $P_2 = P_1$;
 The outlet 2 temperature
 is 179.88°C @
 1000 kPa

$T_2 = 179.88^\circ \text{C}$
 (452.88 K)

B)

(b) mass balance

① $\dot{m}_1 = \dot{m}_2$
 ② $\dot{m}_3 = \dot{m}_4$

Working out h_3 (assuming linear graph):

$h_3 = h_f + x h_{fg}$

$685.74 = 209.34 + 0.2 \times 2382$

$h_3 = 685.74 \text{ kJ/kg}$

Working out h_4 (continued)

$h_f = \frac{(169.88 - 165) \times (719.08 - 697.24)}{(170 - 165)} + 697.24$

$h_f = 718.56 \text{ kJ/kg}$

$h_4 = h_f + x h_{fg} = 718.56 + 0.23 \times 2049.2 = 1189.88$

$h_4 = 1189.88 \text{ kJ/kg}$

working out h_4 :

$(T_4 = 179.88 - 10 = 169.88)^\circ \text{C}$

~~$h_f = \frac{(169.88 - 165) \times (697.24 - 717.86)}{(170 - 165)} + 697.24$~~

~~$h_{fg} = \frac{(169.88 - 165) \times (2065.6 - 2126.69)}{(170 - 165)}$~~

~~$h_{fg} = \frac{(165 - 169.88) \times (2065.6 - 2006.26)}{(170 - 165)}$~~

$h_{fg} = \frac{(169.88 - 165) \times (2048.8 - 2065.6)}{(170 - 165)} + 2065.6$

$h_{fg} = 2049.20 \text{ kJ/kg}$

Question 4)b) continued

energy balance

$$\begin{aligned} 5\% \dot{Q}_i + \dot{Q}_i &= \dot{m}_4 h_4 - \dot{m}_3 h_3 \\ 5\% \dot{Q}_i + \dot{Q}_i &= (5 \times (1189.88 \times 10^3)) - (5 \times (685.74 \times 10^3)) \\ 5\% \dot{Q}_i + \dot{Q}_i &= 2520700 \end{aligned}$$

~~Ans x -1 = -2520700~~ To focus on steam as primary system:

$$0.95 \times (5\% \dot{Q}_i + \dot{Q}_i) = 2394665$$

AMS x -1 = -2394665 To focus on steam as primary system:

$$\dot{Q} = -2394665 \text{ J/s}$$

c) $\dot{Q} = \dot{m}_2 = \dot{m}_1$

$$\begin{aligned} \frac{\dot{Q}}{h_2 - h_1} &= \dot{m}_s = \frac{-2394665}{(762.51 \times 10^3) - (2828.3 \times 10^3)} = 1.16 \\ h_2 &= 762.51 \text{ kJ/kg @ 1000 kPa} \\ h_1 &= 2828.3 \text{ kJ/kg @ 1 MPa } \rightarrow 200^\circ\text{C} \end{aligned}$$

$$\dot{m}_s = 1.16 \text{ kg/s}$$