GENERAL ENGINEERING SCIENCE II

Attempt ALL questions

Marks for each question are shown in brackets.

All formulae used must be stated and the method of working and ALL intermediate steps must be made clear in the answer.

Section A

1. Explain what is meant by EACH of the following terms:

   (a) heat energy; (2)

   (b) higher calorific value; (2)

   (c) convection; (2)

   (d) enthalpy of fusion. (2)

2. (a) State the meaning of the abbreviations 'STP' and 'NTP'. (2)

   (b) 420 grams of a perfect gas has a volume of 0.7 m^3 at a temperature of 92°C The gas is compressed to a quarter of the original volume where its pressure is 200 kN/m^2.

   Determine the final temperature of the gas. 586.441 (6)

   Note: R = 290J/kgK 59.682

   121.8

3. LPG (C_3H_8) is completely burned using 40% excess air.

   Calculate EACH of the following:

   2.999kg (a) the mass of carbon dioxide in the exhaust gases per kg of fuel; (5)

   (b) the mass of nitrogen in the exhaust gases per kg of fuel. (5)

   17.0465

[OVER

4. A brass bearing is to be shrink fitted to a steel shaft. The bearing has an internal bore of 69.82 mm at a temperature of 20°C. The steel shaft has an external diameter of 70 mm at 20°C.

Calculate the lowest temperature to which the bearing must be heated in order to slide onto the shaft without force. (8)

Note: coefficient of linear expansion of brass = 0.000019 / °C

155.687

5. A 2 stroke diesel engine was tested over a 24 hour period and used 1.6 tonnes of fuel. The power of the engine was tested using a dynamometer which gave a steady state torque reading of 4.3 kNm at 750 rpm. The mechanical efficiency was later found to be 89%.

Calculate EACH of the following:

(a) the brake power; 3377212.103W (2)

(b) the indicated specific fuel consumption; 0.01976 (3)

(c) the brake thermal efficiency. 36.8% (3)

Note: the calorific value of the fuel = 44 MJ/kg

6. (a) Describe the basic functions of the key components of a vapour compression refrigeration system. (6)

(b) If the refrigeration system described in Q6(a) has a water cooled condenser what will be the effect of a higher cooling water inlet temperature if the flow rate remains the same. (2)

Section B

7. A ship's compartment becomes flooded with sea water. It has a bulkhead 8 m wide by 9 m deep.

Determine EACH of the following:

(a) the pressure on the bulkhead at its lowest point; 90497 Pa (3)

(b) the thrust on the bulkhead. 3257901 N (5)

Note: seawater density is 1025 kg/m³

8. A ship in even keel has a displacement of 35000 tonnes. Before loading a 250 tonne piece of equipment it is decided to move a 90 tonne load already on board, off the centreline, to incline the ship. The 250 tonne load will act at a point 2 m off the centre line to starboard when added.

Determine EACH of the following:

(a) the distance the 90 tonne load should be moved away from the centreline to incline the ship so that, on loading the 250 tonne equipment, the ship will become level again; (4)

(b) the angle moving the 90 tonne load will create. (4)

Note: Given $m \times d = \Delta\, GM \tan\theta$ *and that* $KM = 7m$, *and* $KG = 5.5$ *m.*

9. A battery has an emf of 48 volts and an internal resistance of 4 ohms. It feeds a circuit consisting of three resistors connected in parallel.

The resistors have values of 10 ohm, 20 ohm and 30 ohm.

Calculate EACH of the following:

(a) the battery terminal voltage; 27.68 (4)

(b) the current in EACH resistor. 2.7, 1.3, 0.9 (4)

35000

[OVER

10. A conductor with an effective length of 200 mm and a diameter of 12 mm carries a current of 30 A at right angles to a magnetic field. The force on the conductor is 18 N.

Calculate EACH of the following:

(a) the flux density; 3 (4)

(b) the magnetic flux. 0.00003392 (4)

11. (a) State how the resistance of metal changes as its temperature rises. (2)

(b) Give an example of where this resistance variation is usefully used. (2)

(c) Determine the total resistance of the circuit shown in Fig Q11. (4)

18.5714

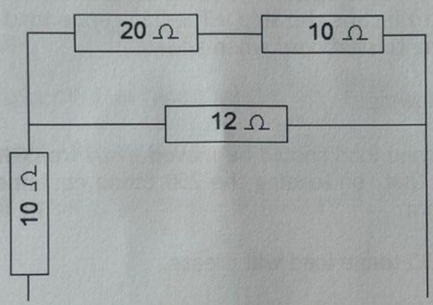


Fig Q11

12. (a) State the difference between a primary and a secondary cell. (2)

(b) Describe, with the aid of a diagram, the electro-chemical action of a lead/acid cell. (8)

1. Explain what is meant by EACH of the following terms:

   (a) heat energy; (2)

   (b) higher calorific value; (2)

   (c) convection; (2)

   (d) enthalpy of fusion. (2)

a)

b)

c)

d)

2. (a) State the meaning of the abbreviations 'STP' and 'NTP'. (2)

(b) 420 grams of a perfect gas has a volume of 0.7 m^3 at a temperature of 92°C The gas is compressed to a quarter of the original volume where its pressure is 200 kN/m^2.

586.441

Determine the final temperature of the gas. (6)

Note: $R = 290 J/kgK$ 59.682

121.8

b) strange question, we dont need the initial conditions

$$P_2 V_2 = m R t$$

$$200{,}000 \times \left(\frac{0.7}{4}\right) = 0.42 \times 290 \times t$$

$$\frac{200{,}000 \times \left(\frac{0.7}{4}\right)}{0.42 \times 290} = t$$

287.356 K

lets check just in case

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$

$PV = mRt$

P

$V = 0.7\ m^3$

$m = 0.42\ kg$

$R = 290$

$t = 92'C + 273 = 365$

$$P = \frac{0.42 \times 290 \times 365}{0.7}$$

$P_1 = 63{,}510\ Pa$

$$\frac{63{,}510 \times 0.7}{365} = \frac{200{,}000 \times \left(\frac{0.7}{4}\right)}{T_2}$$

$$T_2 = \frac{200{,}000 \times \left(\frac{0.7}{4}\right)}{\frac{360034 \times 0.7}{365}}$$

$T_2 = 287.356\ k$

3. LPG (C_3H_8) is completely burned using 40% excess air.

Calculate EACH of the following:

2.999kg (a) the mass of carbon dioxide in the exhaust gases per kg of fuel; (5)

(b) the mass of nitrogen in the exhaust gases per kg of fuel. (5)

17.0465

H = 1 C = 12 O = 16 Air = 23% oxy

Carbon

$3 \times 12 = 36$

Hydrogen

$8 \times 1 = 8$

total

$36 + 8 = 44$

$\frac{36}{44} \times 1kg = 0.818181$ kg

$\frac{8}{44} \times 1kg = 0.181818$ kg

Burn Carbon

$C + O_2 = CO_2$

mols = $\frac{mass}{RAM}$

$\frac{0.818181}{12} = \frac{x}{32}$

2.181818 kg of oxygen Req to burn Carbon

Burn Hydrogen

$H_2 + O = H_2O$

$\frac{0.181818}{2} = \frac{x}{16}$

1.454545 kg of oxygen Req to burn Hydrogen

c) Mass of Carbon + Mass of oxygen = Mass of CO_2

$$0.818181 + 2.18181818 = 2.999999\ kg$$

3 kg

d) Stoich oxy $2.181818\ kg + 1.454545\ kg$

$$= 3.636363\ kg$$

Stoich air @ 23%

$$x\ 0.23 = 3.636363\ kg$$

$$x = \frac{3.636363\ kg}{0.23}$$

$$x = 15.81027\ kg$$

include excess @ 40%

$$15.81027\ kg \times 1.4 = 22.134386\ kg$$

Nitrogen @ 77%

$$22.134386\ kg \times 0.77 = 17.0435\ kg$$

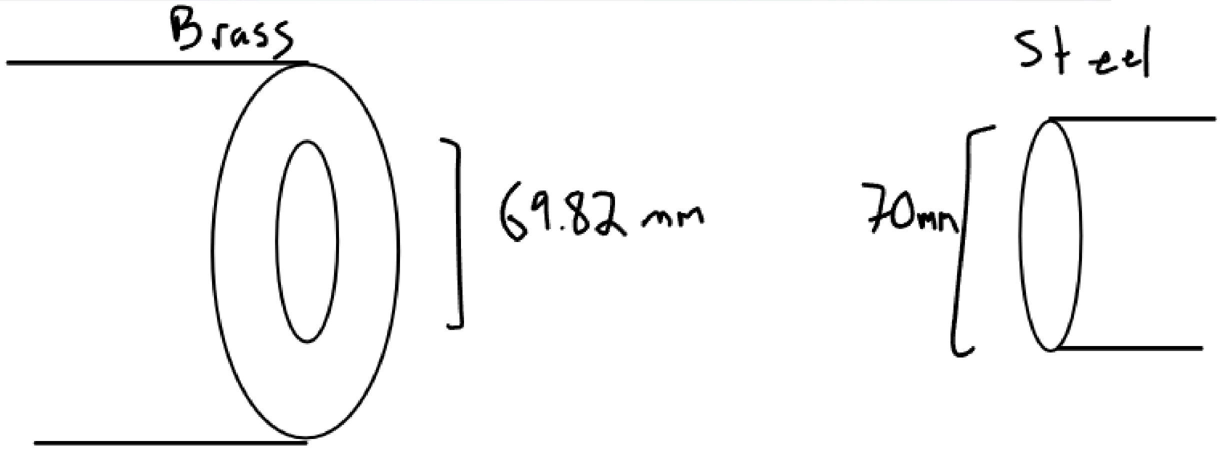
17.0435 kg

4. A brass bearing is to be shrink fitted to a steel shaft. The bearing has an internal bore of 69.82 mm at a temperature of 20°C. The steel shaft has an external diameter of 70 mm at 20°C.

Calculate the lowest temperature to which the bearing must be heated in order to slide onto the shaft without force. (8)

Note: coefficient of linear expansion of brass = 0.000019 / °C

155.687



$$D + \text{expansion} = \text{New dia}$$

$$D + D\alpha\Delta t = \text{New } D$$

$$69.82 + 69.82(0.000019)x = 70$$

$$69.82(0.000019)x = 0.18$$

$$x = \frac{0.18}{69.82(0.000019)}$$

$$\Delta t = 135.6872$$

final temp = initial + Δt

$$20 + 135.6872$$

$$\boxed{155.6872\ ^\circ C}$$

5. A 2 stroke diesel engine was tested over a 24 hour period and used 1.6 tonnes of fuel. The power of the engine was tested using a dynamometer which gave a steady state torque reading of 4.3 kNm at 750 rpm. The mechanical efficiency was later found to be 89%.

Calculate EACH of the following:

(a) the brake power; 3377212.103W (2)

(b) the indicated specific fuel consumption; 0.01976 (3)

(c) the brake thermal efficiency. 36.8% (3)

Note: the calorific value of the fuel = 44 MJ/kg

$$Isfc = \frac{kg}{kwhr} = \frac{\dot{m}\ (kg/h)}{IP\ (kw)}$$

$$B_{te} = \frac{BP\ \text{watt}}{\dot{m}\ (kg/sec)\ \text{cal cont}\ (J/kg)}$$

$$Imep = \frac{A\ \phi}{L}$$

$$IP = x\,p\,l\,a\,n$$

$$BP = T2\pi N$$

$$Eff = \frac{BP}{IP} \times 100$$

a) $BP = T2\pi N$

$T = 4300\ Nm$

$N = 750\ \frac{Rev}{min} \div 60 = 12.5\ Rev/sec$

$BP = 4300 \times 2\pi \times 12.5$

$= 337{,}721.21$ (Watt)

b) $IP = \frac{BP}{Eff}$

$\frac{337721.21}{0.89} = 379462.036 \text{ (watt)}$

379.462 kw

Isfc =

$\text{Fuel consumption} = \frac{1600 \text{ kg}}{24 \text{ hr}} = 66.666 \text{ kg/hr}$

$\text{Isfc} = \frac{66.666 \text{ kg/hr}}{379.462 \text{ kw}} = \boxed{0.17568733 \text{ kg/kwh}}$

c) $Bte = \frac{BP \text{ watt}}{\dot{m}\,(kg/sec)\ \text{cal cont}\ (J/kg)}$

$\dot{m} = \frac{66.666\ kg}{hour} \div 3600 = 0.0185185\ kg/sec$

$Bte = \frac{337,721.21}{0.0185185 \times 44,000,000} \times 100$

41.4476%

6. (a) Describe the basic functions of the key components of a vapour compression refrigeration system. (6)

(b) If the refrigeration system described in Q6(a) has a water cooled condenser what will be the effect of a higher cooling water inlet temperature if the flow rate remains the same. (2)

7. A ship's compartment becomes flooded with sea water. It has a bulkhead 8 m wide by 9 m deep.

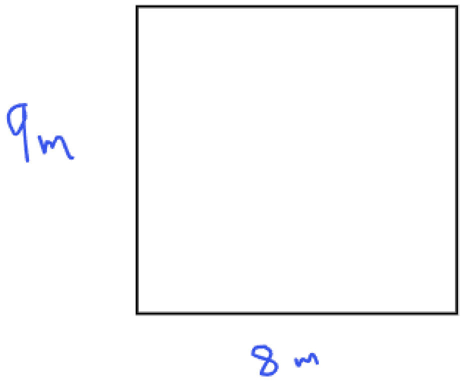
Determine EACH of the following:

(a) the pressure on the bulkhead at its lowest point; 90497 Pa (3)

(b) the thrust on the bulkhead. 3,257,901 N (5)

Note: seawater density is 1025 kg/m^3

a)



$P = \rho g h$

$1025 \times 9.81 \times 9$

90497.25 (Pa)

b)

$F = \rho g A \bar{h}$

$1025 \times 9.81 \times (9 \times 8) \times 4.5$

$= 3{,}257{,}901$ N

8. A ship in even keel has a displacement of 35000 tonnes. Before loading a 250 tonne piece of equipment it is decided to move a 90 tonne load already on board, off the centreline, to incline the ship. The 250 tonne load will act at a point 2 m off the centre line to starboard when added.

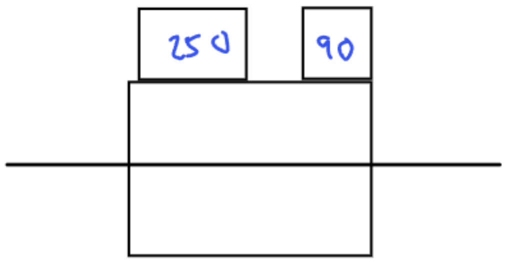
Determine EACH of the following:

(a) the distance the 90 tonne load should be moved away from the centreline to incline the ship so that, on loading the 250 tonne equipment, the ship will become level again; (4)

(b) the angle moving the 90 tonne load will create. (4)

Note: Given m x d = Δ GM tan θ and that KM = 7m, and KG = 5.5 m.

a)



sum of clockwise moments = sum of anticlockwise moments

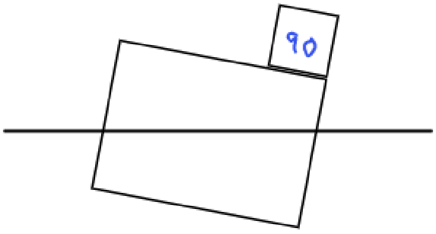
$$M \cdot D = m \cdot d$$

$$250 \times 2 = 90x$$

$$\frac{500}{90} = x$$

5.5555m

b)



$md = \Delta \, GM \tan\theta$

$m = 90$

$d = 5.5555$

$\Delta = 35{,}000$

$GM = 7 - 5.5 = 1.5$

$\theta = x$

$$\frac{90 \times 5.55555}{35{,}000 \times 1.5} = \tan\theta$$

$$\tan^{-1}\left(\quad \right) = \theta$$

0.545657°

9. A battery has an emf of 48 volts and an internal resistance of 4 ohms. It feeds a circuit consisting of three resistors connected in parallel.

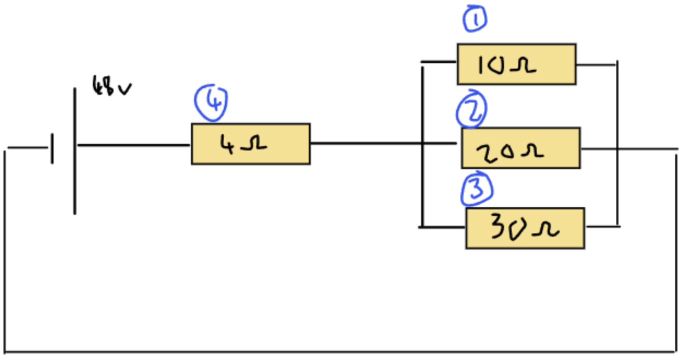
The resistors have values of 10 ohm, 20 ohm and 30 ohm.

Calculate EACH of the following:

(a) the battery terminal voltage; 27.68 (4)

(b) the current in EACH resistor. 2.7, 1.3, 0.9 (4)

35000

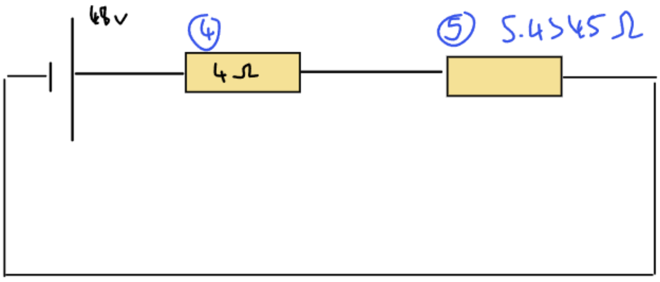


RES over parrallel section R1 R2 R3

$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

$$\frac{1}{R_T} = \frac{1}{10} + \frac{1}{20} + \frac{1}{30}$$

$$R_T = 5.4545\,\Omega$$



RES over series section R4 R5

$$R_T = 4 + 5.4545 = 9.454545\,\Omega$$

$I = \frac{V}{R}$

Circuit

$V = 48$

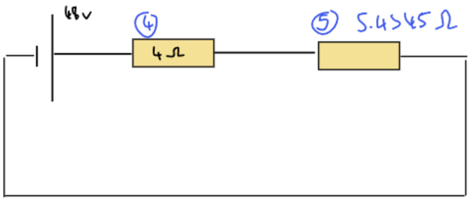
$I = \frac{48}{9.4545} = 5.07692$ Amps

$R = 9.454545$

a)

Emf − IR = terminal

$48 - (5.07692 \times 4) = \boxed{27.6923 \text{ Volts}}$



voltage drop over R4 and R5

④

V = 20.30768 volts

I = 5.07692 Amps

R = 4

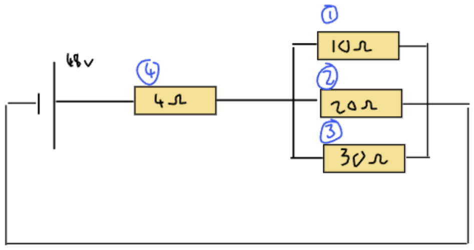
⑤

V = 27.692288 Volt

I = 5.07692 Amps

R = 5.454545

V = I × R



how is amp aplit over R1 R2 R3?

①

V = 27.692288

I = 2.7692288 Amps

R = 10

②

V = 27.692288

I = 1.3846144 Amps

R = 20

③

V = 27.692288

I = 0.923076 Amps

R = 30

$I = \frac{V}{R}$

b) Amp in each Res

I_1 = 2.7692288 Amps

I_2 = 1.3846144 Amps

I_3 = 0.923076 Amps

I_4 = 5.07692 Amps

10. A conductor with an effective length of 200 mm and a diameter of 12 mm carries a current of 30 A at right angles to a magnetic field. The force on the conductor is 18 N.

Calculate EACH of the following:

(a) the flux density; 3 (4)

(b) the magnetic flux. 0.00003392 (4)

a) $F = BIL \sin\theta$

$F = 18$

$B = x$

$I = 30$

$L = 0.2\,m$

$\frac{F}{IL} = B$

$\frac{18}{30 \times 0.2} = B$

3 Tesla = B

b) $B = \frac{\phi}{A}$

$B =$

$\phi = x$

$A = \pi (0.006)^2$

$d = 12\,mm$

$R = 6\,mm = 0.006\,m$

$BA = \phi$

$\phi = \pi (0.006)^2 \times 3 =$ **3.3929×10^{-4} Weber**

11. (a) State how the resistance of metal changes as its temperature rises. (2)

(b) Give an example of where this resistance variation is usefully used. (2)

(c) Determine the total resistance of the circuit shown in Fig Q11. (4)

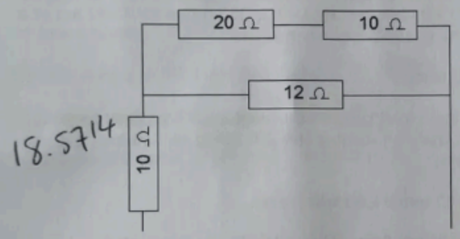
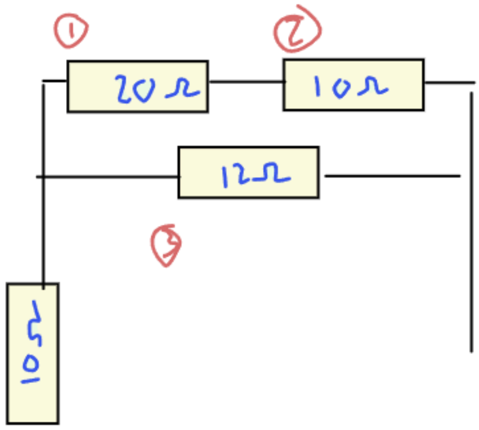


Fig Q11

c)



$R_T = 20 + 10 = 30$

$\frac{1}{R_T} = \frac{1}{30} + \frac{1}{12}$

$R_T = \frac{60}{7} = 8.571428$

$R_T = 18.571428\ \Omega$

12. (a) State the difference between a primary and a secondary cell. (2)

(b) Describe, with the aid of a diagram, the electro-chemical action of a lead/acid cell. (8)