**GENERAL ENGINEERING SCIENCE II**

**Attempt ALL questions**

**Marks for each question are shown in brackets.**

## Section A

1. (a) Why are the units for specific heat capacity J/kgK. (3)

   (b) A bronze casting has a mass of 45 kg and a temperature of 400°C. What is its temperature after losing 5100 kJ of heat energy? (5)

   *Note: Specific Heat Capacity of Bronze = 435 J/kgK.*

2. (a) Define Charles's Law for a perfect gas. (2)

   (b) A perfect gas has a volume of 45 litres at a pressure and temperature of 120 kPa and 30°C respectively. The temperature of the gas rises to 180°C at constant pressure.

   Calculate EACH of the following:

   (i) the increase in the volume of the gas in $m^3$; (3)

   (ii) the mass of gas. (3)

   *Note: for the gas R = 0.29 kJ/kgK*

3. Butane ($C_4H_{10}$) is completely burned in 30% excess air by mass.

   Calculate EACH of the following:

   (a) the mass of carbon dioxide in the exhaust gases per kg of fuel; (4)

   (b) the mass of nitrogen in the exhaust gases per kg of fuel. (4)

4. (a) State TWO desirable properties of refrigerants. (1)

(b) In a vapour compression refrigeration plant, state the primary function of EACH of the following:

(i) the condenser; (3)

(ii) the expansion valve; (3)

(iii) the evaporator. (3)

5. (a) Briefly explain why metals expand when heated. (3)

(b) A copper ball has a diameter of 40.25 mm at a temperature of 550°C.

Calculate the temperature at which the ball will just drop through a hole of 40 mm diameter. (5)

*Note: co-efficient of linear expansion of steel = 0.000018/ °C*

6. Define EACH of the following terms in relation to engine cycles:

(a) Indicated mean effective pressure; (2)

(b) Brake specific fuel consumption; (2)

(c) Mechanical efficiency; (2)

(d) Brake thermal efficiency. (2)

√7. For the circuit shown in Fig Q7 determine:

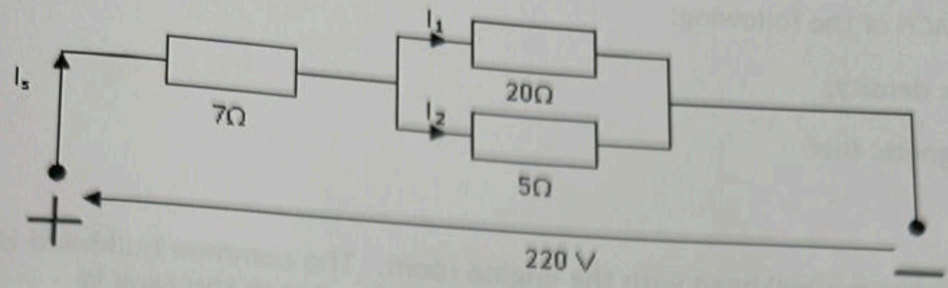


Fig Q7

(a) the supply current, $I_s$; (4)

(b) the potential difference across the 7 Ω resistor; (3)

(c) the current through the 20 Ω resistor. (3)

8. √(a) Briefly explain how the resistance of metals change as the temperature rises. (4)

~~(b)~~ The resistance of the (copper) stator windings of a motor are measured and found to be 240 Ω at 15°C.

The motor is then allowed to warm up, the electrical supply is then isolated and another measurement is taken of the stators windings resistance. The temperature for the second measurement is 65.5°C and the temperature coefficient of resistance (α) for copper at 0°C is 0.0042/°C. (4)

Calculate the value of resistance at this new temperature.

(a) Name TWO sources of electricity. (2)

√(b) What characteristic of the atomic structure of conductors makes them good conductors of electricity, give TWO examples. (3)

√(c) What characteristic of the atomic structure of insulators makes them bad conductors of electricity, give TWO examples. (3)

√10. A conductor with an effective length of 300 mm and a diameter of 9.5 mm when carrying a current of 25 A at right angles to a magnetic field. The force on the conductor is 18 N.

Calculate EACH of the following:

4T (a) the flux density; (4)

$10^{-6}$ W (b) the magnetic flux. (4)

√11. A water tank shares a bulkhead with the engine room. The common bulkhead is rectangular, 3.5 m high and 2 m wide. The amount of water in the tank is measured using a pressure transducer in the base of the tank. The density of water is 1000 kg/m$^3$

Determine EACH of the following:

.5N (a) the thrust on the bulkhead when the tank is filled; (4)

5kPa (b) the pressure indicated on the transducer, in kilopascals, when the tank is half full. (4)

√12. A vessel has a displacement volume of 15000 m$^3$ in sea water of density 1025 kg/m$^3$.

m A double bottom tank measuring 16 m long x 9.5 m wide x 1.8 m deep is positioned symmetrically, either side of the ships centre line and is initially empty.

The tank is now completely filled with fresh water of density 1000 kg/m$^3$.

Calculate the change in position of G, given that the initial KG = 3.8 m. (8)

1. (a) Why are the units for specific heat capacity J/kgK. (3)

(b) A bronze casting has a mass of 45 kg and a temperature of 400°C. What is its temperature after losing 5100 kJ of heat energy? (5)

*Note: Specific Heat Capacity of Bronze = 435 J/kgK.*

b) $Q = mc\Delta t$

$Q = 5{,}100{,}000$ J

$m = 45$ kg

$c = 435$ J/KgK

$\Delta t = x$

$$\frac{Q}{mc} = \Delta t$$

$$\frac{5{,}100{,}000}{45 \times 435} = \Delta t$$

$$260.53 = \Delta t$$

Final temp $= 400 - 260.53 = \boxed{139.463\ ^\circ C}$

2. (a) Define Charles's Law for a perfect gas. (2)

(b) A perfect gas has a volume of 45 litres at a pressure and temperature of 120 kPa and 30°C respectively. The temperature of the gas rises to 180°C at constant pressure.

Calculate EACH of the following:

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(ii) the mass of gas. (3)

*Note: for the gas R = 0.29 kJ/kgK*

b i)

$P_1 = 120{,}000$ Pa $\quad P_2 = 120{,}000$ Pa

$V_1 = 0.045 m^3 \quad V_2 = x$

$T_1 = 30°C = 303$ K $\quad T_2 = 180°C = 453$

$$\frac{P V_1}{T_1} = \frac{P V_2}{T_2}$$

$$\frac{0.045}{303} = \frac{x}{453}$$

$$0.0672772 m^3 = Vol_2$$

increase

$$Vol_2 - Vol_1 = \Delta Vol$$

$$0.0672772 m^3 - 0.045$$

**$0.022277 m^3$ increase**

2. (a) Define Charles's Law for a perfect gas. (2)

(b) A perfect gas has a volume of 45 litres at a pressure and temperature of 120 kPa and 30°C respectively. The temperature of the gas rises to 180°C at constant pressure.

Calculate EACH of the following:

(i) the increase in the volume of the gas in $m^3$; (3)

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b ii)

$$P_1V_1 = m R t_1 \qquad \frac{PV}{Rt} = m$$

$$\frac{120{,}000 \times 0.045}{290 \times 303} = m$$

$$\boxed{0.061454\ Kg}$$

3. Butane ($C_4H_{10}$) is completely burned in 30% excess air by mass.

Calculate EACH of the following:

(a) the mass of carbon dioxide in the exhaust gases per kg of fuel; (4)

(b) the mass of nitrogen in the exhaust gases per kg of fuel. (4)

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

**Carbon**

$4 \times 12 = 48$

$\frac{48}{58} \times 1\,kg = 0.827586\,kg$

**Hydrogen**

$10 \times 1 = 10$

$\frac{10}{58} \times 1\,kg = 0.17241379\,kg$

total 58

**Burn Carbon**

$C + O_2 = CO_2$

$mols = \frac{mass}{RAM}$ $\frac{0.827586}{12} = \frac{x}{32}$

**2.206896 kg** of oxy is req to burn carbon

**Burn Hydrogen**

$H_2 + O = H_2O$

$mols = \frac{mass}{RAM}$ $\frac{0.17241379}{2} = \frac{x}{16}$

**1.37931 kg** of oxy req to burn Hydrogen

3. Butane ($C_4H_{10}$) is completely burned in 30% excess air by mass.

Calculate EACH of the following:

(a) the mass of carbon dioxide in the exhaust gases per kg of fuel; (4)

(b) the mass of nitrogen in the exhaust gases per kg of fuel. (4)

a) Mass of $CO_2$ = mass of Carbon + mass of oxy

= 0.827586 + 2.206896

= 3.034482 kg of $CO_2$

b) stoich oxy 2.206896 + 1.37931 = 3.586206 kg

stoich air @ 23%

$x \times 0.23 = 3.586206$

$x = \frac{3.586206}{0.23} = 15.5922$ kg

include excess @ 30%

include excess @ 30%

15.5922 kg × 1.3 = 20.26986 kg

Nitrogen @ 77%

20.26986 kg × 0.77 = 15.60779 kg

4. (a) State TWO desirable properties of refrigerants. (1)

(b) In a vapour compression refrigeration plant, state the primary function of EACH of the following:

(i) the condenser; (3)

(ii) the expansion valve; (3)

(iii) the evaporator. (3)

5. (a) Briefly explain why metals expand when heated. (3)

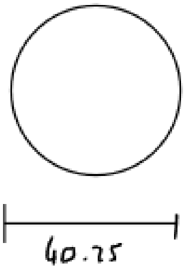
(b) A copper ball has a diameter of 40.25 mm at a temperature of 550°C.

Calculate the temperature at which the ball will just drop through a hole of 40 mm diameter. (5)

Note: *co-efficient of linear expansion of steel = 0.000018/ °C*

typo here

b)




D + expansion = New D

$D + D\alpha\Delta t$

$$40.25 + 40.25(0.000018)x = 40$$

$$40.25(0.000018)x = 40 - 40.25$$

$$x = \frac{-0.25}{40.25(0.000018)}$$

$$\Delta t = x = -345.06556$$

Final temp = initial temp + $\Delta t$

$$550 - 345.06556$$

**204.93 °C**

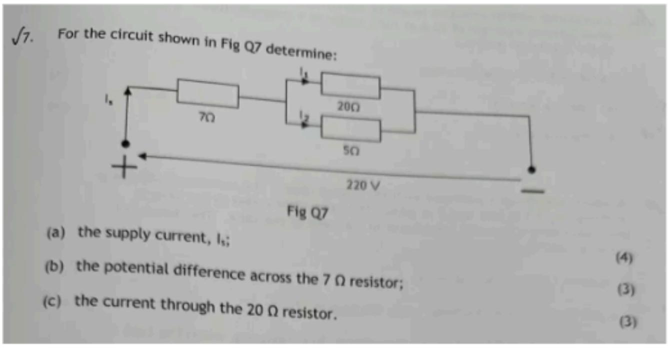
6. Define EACH of the following terms in relation to engine cycles:

(a) Indicated mean effective pressure; (2)

(b) Brake specific fuel consumption; (2)

(c) Mechanical efficiency; (2)

(d) Brake thermal efficiency. (2)



7. For the circuit shown in Fig Q7 determine:

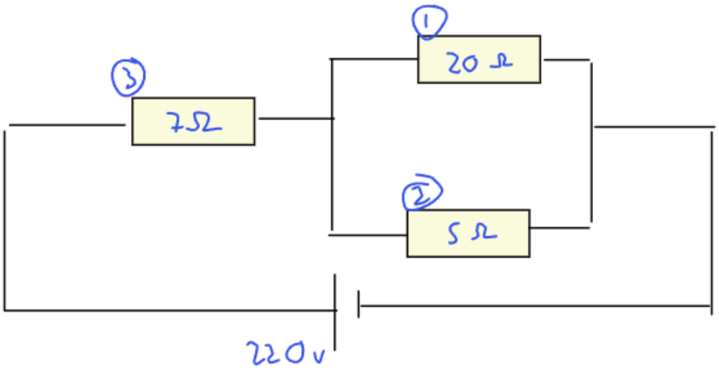


Fig Q7

(a) the supply current, $I_s$; (4)

(b) the potential difference across the 7 Ω resistor; (3)

(c) the current through the 20 Ω resistor. (3)



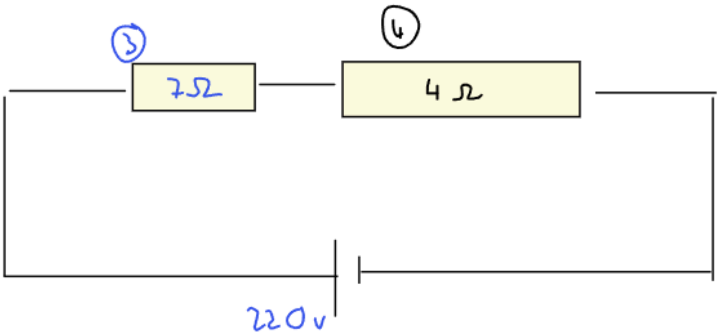

RES in parrallel R1 R2

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

$$\frac{1}{R_T} = \frac{1}{20} + \frac{1}{5}$$

$$R_T = 4\ \Omega$$

res in series




$$R_T = R_3 + R_4$$

$$7 + 4 = 11\ \Omega$$

Circuit

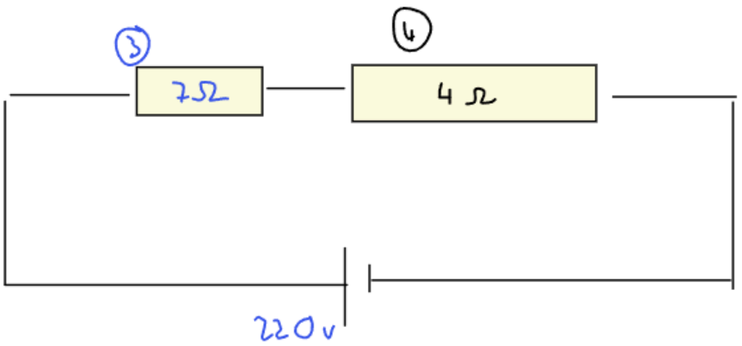

$$I = \frac{V}{R} = \frac{220}{11}$$

$V = 220$

$I = 20$ Amps

$R = 11$

a) supply current 20 Amps

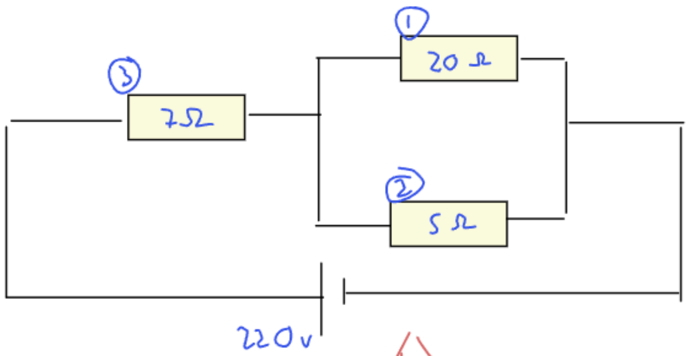



voltage drop over R3 R4

| ③ | ④ |
|---|---|
| V = 140 v | V = 80v |
| I = 20 | I = 20 |
| R = 7 | R = 4 |


$V = I \times R$

b) Pd across 7Ω = 140v




how is current split over R1 R2

| ① | ② |
|---|---|
| V = 80 | V = 80 |
| I = 4 A | I = 16 A |
| R = 20 | R = 5 |


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

c) current in 20Ω = 4A

8. (a) Briefly explain how the resistance of metals change as the temperature rises. (4)

(b) The resistance of the (copper) stator windings of a motor are measured and found to be 240 Ω at 15°C.

The motor is then allowed to warm up, the electrical supply is then isolated and another measurement is taken of the stators windings resistance. The temperature for the second measurement is 65.5°C and the temperature coefficient of resistance (α) for copper at 0°C is 0.0042/°C.

Calculate the value of resistance at this new temperature. (4)

first we find the resistance at zero degree C, this is our reference temp

$R_0 = x$

$R_{15} = 240\ \Omega$

$\alpha = 0.0042\ /°C$

$\Delta t = 15$

$R_0(1 + \alpha \Delta t) = R_t$

$x(1 + 0.0042(15)) = 240$

$R_0 = x = 225.7761\ \Omega$

next find res at target temp (65ºC)

$R_{65} = x$

$R_0(1 + \alpha \Delta t) = R_{65}$

$225.7761(1 + 0.0042 \times 65)$

$\boxed{287.413\ \Omega = R_{65}}$

10. A conductor with an effective length of 300 mm and a diameter of 9.5 mm when carrying a current of 25 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; (4)

(b) the magnetic flux. (4)

a) $F = BIL\sin\theta$

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

$\frac{18}{25 \times 0.3} = B$

$2.4\ T = B$

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

$BA = \phi$

$2.4 \times \left(\frac{9.5}{2000}\right)^2 \pi$

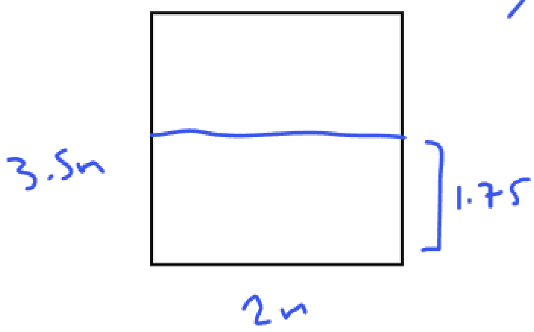
$1.70172 \times 10^{-4}\ Wb$

1. A water tank shares a bulkhead with the engine room. The common bulkhead is rectangular, 3.5 m high and 2 m wide. The amount of water in the tank is measured using a pressure transducer in the base of the tank. The density of water is 1000 kg/m$^3$

Determine EACH of the following:

N (a) the thrust on the bulkhead when the tank is filled; (4)

kPa (b) the pressure indicated on the transducer, in kilopascals, when the tank is half full. (4)




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

$= 1000 \times 9.81 \times (3.5 \times 2) \times \left(\frac{3.5}{2}\right)$

**120172.5 N**

b) $P = \rho g h$

$1000 \times 9.81 \times 1.75$

$17167.5$ (Pa)

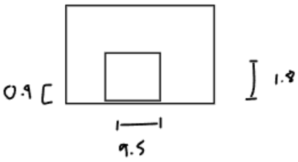
**17.1675 kPa**

12. A vessel has a displacement volume of 15000 $m^3$ in sea water of density 1025 $kg/m^3$.

A double bottom tank measuring 16 m long x 9.5 m wide x 1.8 m deep is positioned symmetrically, either side of the ships centre line and is initially empty.

The tank is now completely filled with fresh water of density 1000 $kg/m^3$.

Calculate the change in position of G, given that the initial KG = 3.8 m. (8)




Mass ship

$m = d \times v$

$1.025 \times 15000 = 15375$ t

Mass load

$m = d \times vol$

$1.000 \times (16 \times 9.5 \times 1.8)$

273.6 t

| Name | Mass (t) | Force | Dist (m) | Moment (t m) | Dir |
|---|---|---|---|---|---|
| Ship | 15375 | | 3.8 | 58425 | C |
| load | 273.6 | | 0.9 | 246.24 | C |
| Ship + load | 15648.6 | | $x$ | 15648.6$x$ | A |

sum of the clockwise moments = sum of the anticlockwise moments

$58425 + 246.24 = 15648.6x$

3.74929 = New KG

change in KG = Old KG − New KG

3.8 − 3.74929

= 0.0507035 m

**−0.0507035 m** change KG