GENERAL ENGINEERING SCIENCE II

Attempt ALL questions

Marks for each question are shown in brackets.

Section A

1. (a) Explain what is meant by the term specific heat capacity and why are the units J/kgK. (4)

   (b) An iron casting has a mass of 30 kg and a temperature of 400°C. Determine its temperature after losing 1950 kJ of heat energy. (4)

   Note: Specific Heat Capacity of Cast Iron = 477 J/kgK

2. (a) Explain why metals expand as their temperature rises. (3)

   (b) A copper ball has a diameter of 55.25 mm at a temperature of 595°C.

   Calculate the temperature at which the ball will just drop through a hole of 54.95 mm. (5)

   Note: Co-efficient of linear expansion of copper = 0.0000167/°C

3. Argon has a volume of 0.7 m^3 at 3.5 bar and a temperature of 25°C. The Argon is now heated in its vessel until the pressure reaches 1.05 MN/m^2 the volume is unchanged.

   Determine EACH of the following:

   (a) the mass of Argon; (4)

   (b) the final temperature of the Argon. (4)

   Note: The characteristic gas constant for Argon has a value of 208 J/kgK.

4. A perfect gas at an initial pressure, temperature and volume of 10 bar, 28°C and 74 litres respectively is compressed according to Boyle's Law until the volume is 26 litres.

Heating then causes an expansion according to Charles's Law until the temperature is 180°C.

Determine EACH of the following:

(a) the final pressure; (3)

(b) the final volume; (3)

(c) the mass of gas. (3)

Note: R = 0.29 kJ/kgK

5. A diesel engine uses 28 kg of fuel per hour. The indicated power of the engine is 132 kW and the mechanical efficiency is 91%.

Determine EACH of the following:

(a) the brake power; (3)

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

(c) the brake thermal efficiency. (3)

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

6. (a) State TWO desirable properties of refrigerants. (2)

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

(i) the condenser; (2)

(ii) the expansion valve; (2)

(iii) the evaporator. (2)

Section B

7. A circuit consists of three resistors connected in parallel. The resistors have values of 150 ohm, 220 ohm and 180 ohm. The circuit is powered from a battery which has an e.m.f. of 29 volts and an internal resistance of 4 ohms.

Determine EACH of the following:

(a) the battery terminal voltage; (5)

(b) the current in EACH resistor. (3)

8. Fig Q8 shows TWO 12 V lamps, EACH of 4 Ω resistance connected in parallel across a 20 V supply.

To avoid exceeding the current rating for the lamps a resistor of 1.33 Ω is connected in series with the supply.

Determine EACH of the following:

(a) the power dissipated by each lamp; (5)

(b) the power dissipated by the 1.33 Ω resistor; (2)

(c) the total energy used by the circuit in 30 minutes. (3)

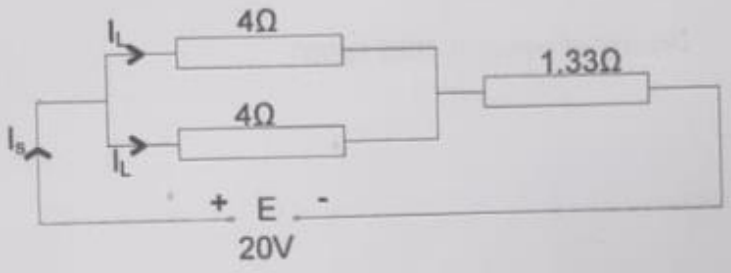


FIG Q8

9. (a) State the THREE main effects of an electric current. (3)

(b) State TWO practical examples of EACH effect in Q9(a). (3)

(c) List FOUR means by which electricity may be produced. (2)

10. (a) State Lenz's Law. (3)

(b) A conductor with an effective length of 300 mm creates a magnetic flux of 250 μWb when carrying a current of 45 A at right angles to a magnetic field. The force on the conductor is 34 N.

Determine the diameter of the conductor. (5)

11. A ship of 10000 tonne displacement has a rectangular fuel tank 15 m long, 12 m wide and 4 m deep. The tank is across the centreline and is full of fuel oil with a density of 900 kg/m^3 and the tank bottom is 1.2 m above the keel. The KG of the vessel is 6.2 m when the tank is full.

Determine the new KG after all of the oil has been used. (8)

12. (a) State Archimedes principle. (2)

(b) After discharging ballast at a depth of 30 m underwater an ROV can be equated to an empty sphere of 700 mm diameter.

Determine EACH of the following:

(i) the buoyancy force on the ROV; (3)

(ii) the pressure on the ROV. (3)

Note: Density of water is 1020 kg/m^3

1. (a) Explain what is meant by the term specific heat capacity and why are the units J/kgK. (4)

(b) An iron casting has a mass of 30 kg and a temperature of 400°C. Determine its temperature after losing 1950 kJ of heat energy. (4)

Note: Specific Heat Capacity of Cast Iron = 477 J/kgK

b) $Q = m c \Delta t$

$1950{,}000 = 30 \times 477 \times \Delta t$

$136.2683 = \Delta t$

$400 - 136.2683 = 263.73^{\circ}C$

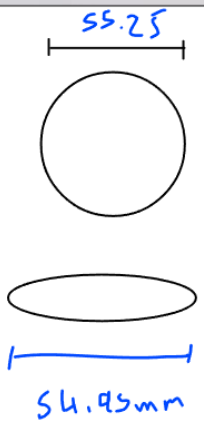
2. (a) Explain why metals expand as their temperature rises. (3)

(b) A copper ball has a diameter of 55.25 mm at a temperature of 595°C.

Calculate the temperature at which the ball will just drop through a hole of diameter 54.95 mm. (5)

Note: Co-efficient of linear expansion of copper = 0.0000167/°C

b)



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

$55.25 + 55.25 \times 0.0000167 \times \Delta t = 54.95$

$\Delta t = \frac{-0.3}{9.22675 \times 10^{-4}}$

$\Delta t = -325.14157$

$595 - 325.14157 = 269.858\ ^\circ C$

3. Argon has a volume of 0.7 m^3 at 3.5 bar and a temperature of 25°C. The Argon is now heated in its vessel until the pressure reaches 1.05 MN/m^2 the volume is unchanged.

Determine EACH of the following:

(a) the mass of Argon; (4)

(b) the final temperature of the Argon. (4)

Note: The characteristic gas constant for Argon has a value of 208 J/kgK.

a) $PV = mRt$

$350{,}000 \times 0.7 = x \times 208 \times (25+273)$

$$\frac{245000}{61984} = x$$

$3.9526\ kg$

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

$\frac{350,000}{298} = \frac{1,050,000}{x}$

$x = \frac{1,050,000}{1174.4966}$

$x = 894\,k$

4. A perfect gas at an initial pressure, temperature and volume of 10 bar, 28°C and 74 litres respectively is compressed according to Boyle's Law until the volume is 26 litres.

Heating then causes an expansion according to Charles's Law until the temperature is 180°C.

Determine EACH of the following:

(a) the final pressure; (3)

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(c) the mass of gas. (3)

Note: R = 0.29 kJ/kgK

4c)

$P_1 = 1{,}000{,}000\ (Pa)$

$T_1 = 28 + 273 = 301\ K$

$V_1 = 0.074\ m^3$

$P_2 = x$

$T_2 = 301$

$V_2 = 0.026$

$P_3 = x$

$T_3 = (180 + 273) = 453$

$V_3 = y$

a) $P_1 V_1 = P_2 V_2$

$\frac{1{,}000{,}000}{0.026} \times 0.074 = P_2$

$2{,}846{,}153.846\ (Pa)$

b) $\frac{V_2}{T_2} = \frac{V_3}{T_3}$

$\frac{0.026}{301} \times 453 = V_3$

$0.039129\ m^3$

c) $PV = mRt$

$\frac{1{,}000{,}000 \times 0.074}{290 \times 301} = m$

$0.847748\ kg$

5. A diesel engine uses 28 kg of fuel per hour. The indicated power of the engine is 132 kW and the mechanical efficiency is 91%.

Determine EACH of the following:

(a) the brake power; (3)

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

(c) the brake thermal efficiency. (3)

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

a) $IP = 132\ kW \qquad Eff = 0.91$

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

$0.91 \times 132 = 120.12\ kW$

b) $Isfc = \frac{\dot{m}}{IP} = \frac{28\ kg/h}{132\ kW} = 0.2121\ kg/kWh$

c) $BTE = \frac{BP}{\dot{m} \times Cal} = \frac{120120}{0.0077777 \times 44 \times 10^6} = 0.351 = 35.1\%$

6. (a) State TWO desirable properties of refrigerants. (2)

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

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Section B

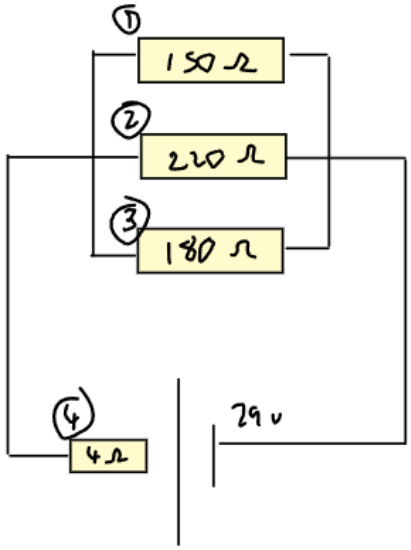
7. A circuit consists of three resistors connected in parallel. The resistors have values of 150 ohm, 220 ohm and 180 ohm. The circuit is powered from a battery which has an e.m.f. of 29 volts and an internal resistance of 4 ohms.

Determine EACH of the following:

(a) the battery terminal voltage; (5)

(b) the current in EACH resistor. (3)

a)



$$\frac{1}{R_T} = \frac{1}{150} + \frac{1}{220} + \frac{1}{180}$$

$R_T = 59.639\ \Omega + 4$

$R_T = 63.639\ \Omega$

circuit

$V = 29v$

$I = 0.486262$

$R = 63.639$

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

$\frac{29}{63.639} = 0.486262$

Emf − IR = terminal voltage.

$29 - 0.486262 \times 4 = 27.054949$ Volts

b)

(1) $V = 27.05495$ $I = 0.180386$ Amp $R = 150$

(2) $V = 27.05495$ $I = 0.122977$ Amp $R = 220$

(3) $V = 27.05495$ $I = 0.150305$ Amp $R = 180$

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

8. Fig Q8 shows TWO 12 V lamps, EACH of 4 Ω resistance connected in parallel across a 20 V supply.

To avoid exceeding the current rating for the lamps a resistor of 1.33 Ω is connected in series with the supply.

Determine EACH of the following:

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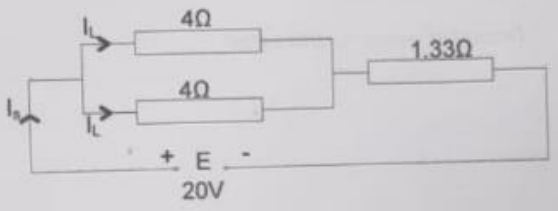


FIG Q8

a) $\frac{1}{R_T} = \frac{1}{4} + \frac{1}{4} = \frac{1}{2}$

$R_T = 2 + 1.33 = 3.33$

$V = 20$

$I = 6.006$ Amps

$R = 3.33$

$I = \frac{20}{3.33} = 6.006$

Voltage drop over 1.33 Ω

$V = 7.987V$

$I = 6.006$

$R = 1.33$

V

I R

$V = I \times R$

$V = 7.987V$

Supply voltage to lamps

$$20 - 7.987V = 12.012012V$$

$P = IV$

$P = 3.003 \times 12.012012$

$P = 36.072$ Watts

b) $P = IV$

$P = 7.987 \times 6.006$

$= 47.969922$ Watts

c) $P = IV$

6.006×20

120.12 Watts $= \frac{J}{S} \times 60 \times 30$

216216 J/s

9. (a) State the THREE main effects of an electric current. (3)

(b) State TWO practical examples of EACH effect in Q9(a). (3)

(c) List FOUR means by which electricity may be produced. (2)

10. (a) State Lenz's Law. (3)

(b) A conductor with an effective length of 300 mm creates a magnetic flux of 250 μWb when carrying a current of 45 A at right angles to a magnetic field. The force on the conductor is 34 N.

Determine the diameter of the conductor. (5)

$F = BIL\sin\theta$

$34 = B \times 45 \times 0.3$

$\frac{34}{45 \times 0.3} = B$

$2.518518\ \text{Tesla} = B$

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

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

$\pi r^2 = \frac{250 \times 10^{-6}}{2.518518}$

$r = 5.621115301 \times 10^{-3}\ m$

$d = 0.011242223\ m$

11. A ship of 10000 tonne displacement has a rectangular fuel tank 15 m long, 12 m wide and 4 m deep. The tank is across the centreline and is full of fuel oil with a density of 900 kg/m^3 and the tank bottom is 1.2 m above the keel. The KG of the vessel is 6.2 m when the tank is full.

Determine the new KG after all of the oil has been used. (8)

tank $15 \times 12 \times 4 \times 0.9 = 648$ t

	Mass (t)	Distance	Direction
ship	9352	x	C
load	648	3.2	C
ship + load	10,000	6.2	AC

$10{,}000 \times 6.2 = 648 \times 3.2 + 9352x$

$$\frac{62{,}000 - 1113.6}{9352} = x$$

$6.51052 = kg$

12. (a) State Archimedes principle. (2)

(b) After discharging ballast at a depth of 30 m underwater an ROV can be equated to an empty sphere of 700 mm diameter.

Determine EACH of the following:

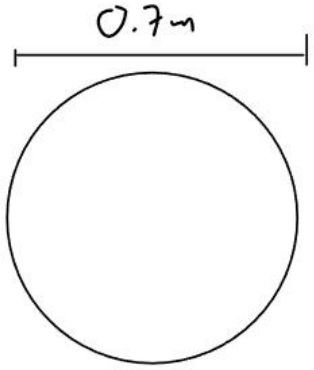
(i) the buoyancy force on the ROV; (3)

(ii) the pressure on the ROV. (3)

Note: Density of water is 1020 kg/m³

a) Archimedes principal states that the volume of the water displaced will be the same and the volume of the object sumberged.

b)



i) buoyancy force:
The volume of the ROV = Volume of water displaced

$\frac{4}{3}\pi r^3$

$\frac{4}{3}\pi (0.35)^3 = 0.17959438$

mass of water displaced

density x vol = mass

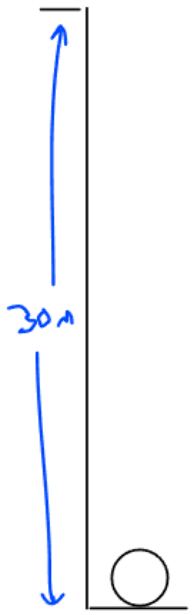
$1020 \times 0.17959438 = 183.1862676$ kg

lets convert this to a force multiplying by 9.81

$183.1862676 \times 9.81 = 1797.057$ N

Buoyancy force ↑

c) $P = \rho g h$



the pressure on the top of the ROV will be less than on the bottom, I can find the max pressure, min pressure or the average pressure. The question doesnt specifiy.

max Pressure is $h = 30$

$P = 1020 \times 9.81 \times 30 = 300186$ (P_a)