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 enthalpy of fusion. (2)

   (b) 100 grams of ice at -5°C is heated with 40 kJ of energy.

   Determine the final state and temperature. (6)

   Note: *Specific heat capacity of ice = 2.11kJ/kgK,*
   Specific heat capacity of water = 4.18kJ/kgK,
   Enthalpy of fusion of water = 335kJ/kg

2. (a) State Boyles Law. (2)

   (b) A perfect gas at an initial pressure, temperature and volume of 2.75 bar, 185°C and 90 litres respectively is cooled at constant pressure until its temperature is 15°C.

   Determine EACH of the following:

   (i) the initial mass of the gas; (3)

   (ii) the final volume in m^3. (3)

   Note: *R = 0.29 kJ/kgK*

3. An 8 cylinder, 4 stroke diesel has a cylinder bore of 350 mm with a stroke of 400 mm. Indicator cards were taken and each had a mean effective height of 22 mm.

The power of the engine was also tested using a dynamometer which gives a steady state torque reading of 36 kNm at 800 rpm.

Determine EACH of the following:

(a) the brake power; (3)

(b) the indicated power; (3)

(c) the mechanical efficiency. (2)

Note: Indicator spring constant was 80 $kN/m^2/mm$

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

(b) 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)

5. 1.5 kg of C_3H_7 is completely burned in air.

Determine EACH of the following:

(a) the stoichiometric mass of air required; (4)

(b) the mass of carbon dioxide in the exhaust gases. (4)

Note: assume air is 23% oxygen by mass

6. At point 1 of a cyclic process 0.2 m^3 of air at 1.01325 bar and 20°C occupies a cylinder at bottom dead centre. Assume that losses are negligible:

(a) at top dead centre, point 2, the gas has been compressed to one tenth of its original volume at point 1. Determine the pressure assuming no temperature rise; (2)

(b) at top dead centre there is a heat addition of 60kJ which causes a pressure rise at constant volume to point 3. Determine the pressure as a result of this process; (6)

(c) the cycle continues with an expansion from point 3 back to bottom dead centre, point 4, determine the final pressure at point 4 if the temperature remains constant in this process. (2)

Note: R = 0.287 kJ/kgK, Cv = 0.718 kJ/kgK

Section B

7. (a) State two sources of electricity. (2)

(b) Describe the characteristic of the atomic structure of conductors that makes them good conductors of electricity and give TWO examples. (3)

(c) Describe the characteristic of the atomic structure of insulators that makes them bad conductors of electricity and give TWO examples. (3)

8. For the circuit shown in FIG Q8 which has a battery e.m.f. of 24 V.

Determine EACH of the following:

(a) the battery terminal voltage; (4)

(b) the current at points 3, 2 and 1 in the circuit. (4)

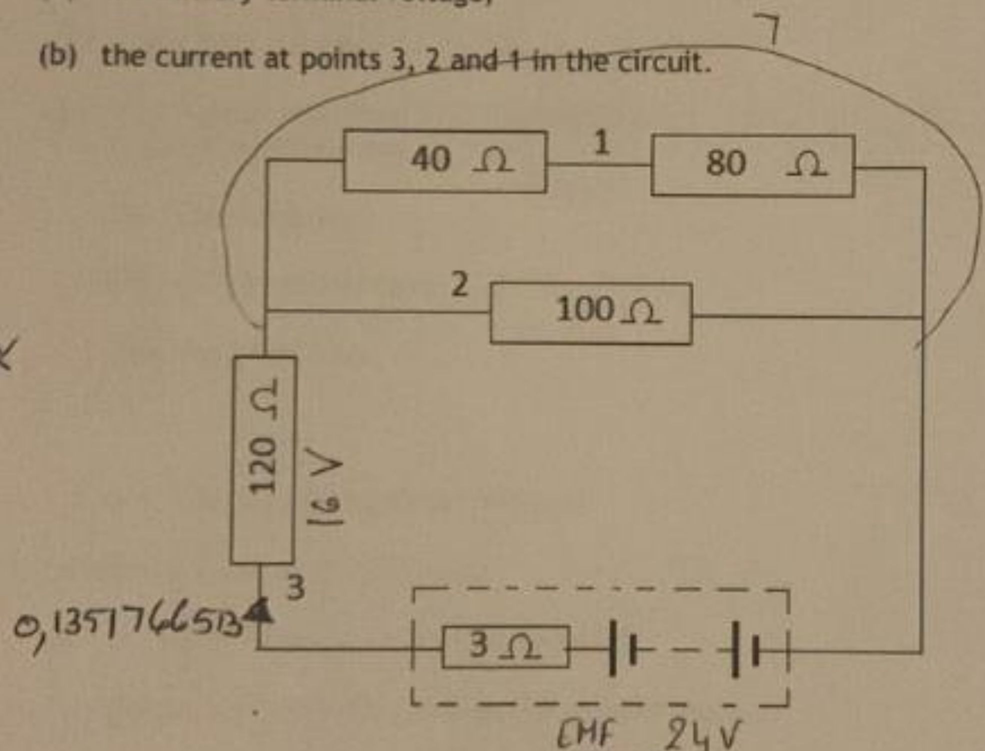


FIG Q8

9. (a) State what is 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)

10. (a) State Lenz's Law. (2)

(b) A conductor with an effective length of 500 mm creates a magnetic flux of 280 μWb when carrying a current of 45 A at right angles to a magnetic field.

The force on the conductor is 40 N.

Calculate the diameter of the conductor. (6)

11. A barge is in dry dock as shown in FIG Q11. The dry dock is rectangular with a length of 70 m and a breadth of 30 m. The dry dock is flooded and the barge, which has a beam of 20 m and a length of 62 m, just floats off the blocks when the water depth is 4.4 m. The barge displaces 6234 m^3 of seawater of relative density 1.025.

Determine EACH of the following:

(a) the mass of the barge; (5)

(b) the pressure on the bottom of the hull plating. Assume the barge to be a rectangular box barge. (3)

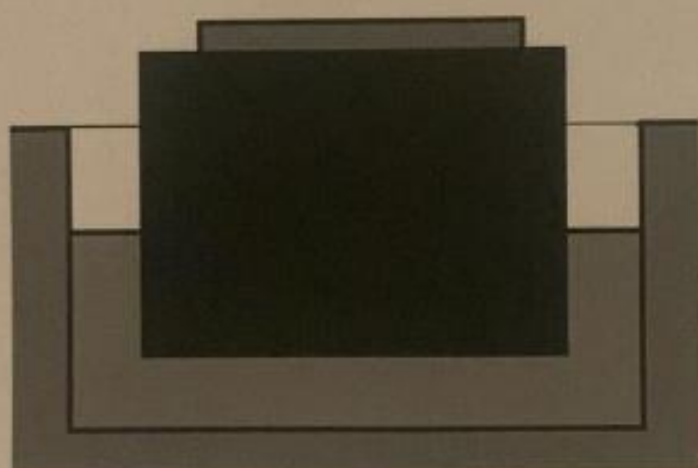


FIG Q11

12. A vessel has a displacement volume of 19000 m^3 in sea water. It has a rectangular fuel tank 10 m long, 8 m wide and 4 m deep. The tank 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.

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

Note: the relative density of sea water is 1.025

1. (a) Explain what is meant by the enthalpy of fusion. (2)

(b) 100 grams of ice at -5°C is heated with 40 kJ of energy.

Determine the final state and temperature. (6)

Note: *Specific heat capacity of ice = 2.11kJ/kgK,*
Specific heat capacity of water = 4.18kJ/kgK,
Enthalpy of fusion of water = 335kJ/kg

a) enthalpy of fusion is the amount of energy per kilogram required to bring about a state change of a material from a solid to a liquid or vice versa.

Units J/Kg

$Q_{Fusion} = m \cdot L$

mass × latent

ice −5°C —(heat the ice)→ ice 0°C —(melt ice)→ water 0°C —(heat water)→ Water x°C

Heat the ice from -5 to 0

$Q = mc\Delta t$

0.1 × 2110 × 5

= 1055 J

melt the ice into water

$Q = mc$

= 0.1 × 335,000

33500 J

heat the water from 0°C upwards

40,000 − (1055 + 33500) = 5445 J

$Q = mc\Delta t$

5445 = 0.1 × 4180 × Δt

Δt = 13.026 °C

13.026 °C Find temp of water (liquid)

2. (a) State Boyles Law. (2)

(b) A perfect gas at an initial pressure, temperature and volume of 2.75 bar, 185°C and 90 litres respectively is cooled at constant pressure until its temperature is 15°C.

Determine EACH of the following:

(i) the initial mass of the gas; (3)

(ii) the final volume in m^3. (3)

Note: $R = 0.29\ kJ/kgK$

a) Boyles Law states that a decrease in volume will lead to an increase in pressure, at a constant temperature for a perfect gas.

b) i) $Pv = mRt$

$P = 275{,}000$ (Pa)

$v = 0.09\ m^3$

$m = x$

$R = 290$

$t = 185 + 273 = 458\ °C$

$275{,}000 \times 0.09 = x \cdot 290 \times 458$

$$\frac{275{,}000 \times 0.09}{(290 \times 458)} = x$$

0.18634 Kg

ii)

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

$$\frac{0.09}{458} = \frac{x}{288}$$

$$0.056593 \text{ m}^3 = V_2$$

3. An 8 cylinder, 4 stroke diesel has a cylinder bore of 350 mm with a stroke of 400 mm. Indicator cards were taken and each had a mean effective height of 22 mm.

The power of the engine was also tested using a dynamometer which gives a steady state torque reading of 36 kNm at 800 rpm.

Determine EACH of the following:

(a) the brake power; (3)

(b) the indicated power; (3)

(c) the mechanical efficiency. (2)

Note: Indicator spring constant was 80 kN/m²/mm

height

$Imep = \frac{A \phi}{L}$ (A → height)

$IP = x\,plan$ $\quad BP = T\,2\pi n$ $\quad Eff = \frac{BP}{IP} \times 100$

a) $BP = 36{,}000 \times 2\pi \times 13.333 = 3015921.408$ Watts

$n = 800 \div 60 = 13.333$

b) $IP = x\,p\,l\,a\,N$

$x = 8$

$p = 22 \times 80{,}000 = 1{,}760{,}000\ N/m^2$ (17.6 bar!!! high pressure!)

$L = 0.4\ m$

$a = \pi\left(\frac{0.35}{2}\right)^2 = 0.096211\ m^2$

$N = \left(\frac{800}{60}\right) \div 2 = 6.66667$

$IP = 8 \times 1{,}760{,}000 \times 0.4 \times 0.096211 \times 6.66667$

$IP = 3612412.669$ Watts

c) $eff = \frac{3015921.408}{3612413} \times 100 = 83.4877\%$

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

(b) 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)

a) non toxic, non ozone depleating, non corrosive, high lantent heat, low freezing point, low boiling point.

bi)

5. 1.5 kg of C_3H_7 is completely burned in air.

Determine EACH of the following:

(a) the stoichiometric mass of air required; (4)

(b) the mass of carbon dioxide in the exhaust gases. (4)

Note: assume air is 23% oxygen by mass

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

1.5 kg of C_3H_7

Carbon

$C_3 = 12 \times 3 = 36$

mass $\frac{36}{43} \times 1.5 = 1.2558$ kg

Burn the Carbon

$C + O_2 = CO_2$

mols = $\frac{mass}{RAM}$ $\frac{1.2558}{12} = \frac{x}{32}$

x = 3.3488 kg of oxygen to burn Carbon

Hydrogen

$H_7 = 1 \times 7 = 7$

$\frac{7}{43} \times 1.5 = 0.244186$ kg

Burn the hydrogen

mols = $\frac{mass}{RAM}$ $H_2 + O = H_2O$

$\frac{0.244186}{2} = \frac{x}{16}$

x = 1.953488 Kg of oxygen Req to burn hydrogen

total

$C_3H_7 = 3 \times 12 + 7 = 43$

(stoich) tdd oxygen $3.3488 + 1.953488 = 5.302288$ kg

a) stoich Air : $\frac{5.302288}{0.23} = 23.0534$ kg air

b) $CO_2 = C + O_2$

$1.2558 + 3.3488 = 4.6046$ kg

CO_2 in exhaust 4.6046 kg

6. At point 1 of a cyclic process 0.2 m^3 of air at 1.01325 bar and 20°C occupies a cylinder at bottom dead centre. Assume that losses are negligible:

(a) at top dead centre, point 2, the gas has been compressed to one tenth of its original volume at point 1. Determine the pressure assuming no temperature rise; (2)

(b) at top dead centre there is a heat addition of 60kJ which causes a pressure rise at constant volume to point 3. Determine the pressure as a result of this process; (6)

(c) the cycle continues with an expansion from point 3 back to bottom dead centre, point 4, determine the final pressure at point 4 if the temperature remains constant in this process. (2)

Note: R = 0.287 kJ/kgK, Cv = 0.718 kJ/kgK

Point 1 (BDC) Point 2 (TDC)

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

$P_1 = 101{,}325$ (Pa)

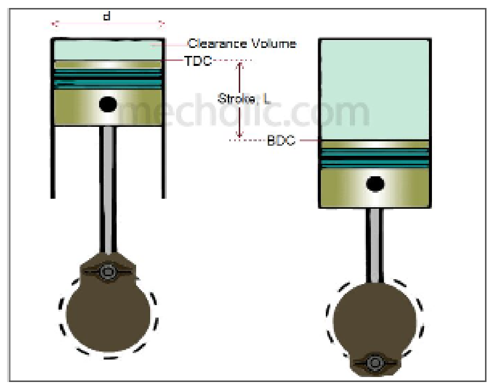
$V_1 = 0.2$ (m^3)

$T_1 = 20°C = 293$ K

$P_2 = x = 1013250$

$V_2 = 0.02$ m^3

$T_2 = 293$



a) $P_1 V_1 = P_2 V_2$

$101{,}325 \times 0.2 = 0.02\, x$

$$\frac{101\,325 \times 0.2}{0.02} = 1{,}013{,}250$$

$P_2 = 1013250$ (Pa)

b) (TDC)

$Q = mc\Delta t$

$Q = 60{,}000J$

$m = ?$

$c = 718$

$\Delta t = x$

$Pv = mRt$

We dont know the mass of the gas, we can find this from the inital conditions.

$P = 1013250$

$V = 0.02$

$m = x$

$R = 287$

$t = 293k$

$1013250 \times 0.02 = x \times 287 \times 293$

mass = 0.2409889287 kg

$Q = mc\Delta t$

$60{,}000 = 0.240988927 \times 718 \times \Delta t$

$$\frac{60{,}000}{(0.240988927 \times 718)} = \Delta t$$

$346.76 = \Delta t$

Find temp = initial + Δt

$293 + 346.76$

$= 639.76\ k$

calc Pressure $V_2 = V_3$

$$\frac{P_2 V_2}{T_2} = \frac{P_3 V_3}{T_3}$$

$$\frac{1013250}{293} = \frac{x}{639.76}$$

2,212,414 (Pa) = x

(BDC)

$$\frac{P_3 V_3}{T_3} = \frac{P_4 V_4}{T_4}$$

$P_3 = 2,212,414$ $P_4 = x$

$V_3 = 0.02$ $V_4 = 0.2$

to get these volumes we need to look over the previous steps, V4 is BDC (bottom dead centre) so we know its volume, and V3 is the same as V2

$$2212414 \times 0.02 = x \times 0.2$$

$$P = 221,241.4345 \; (P_4)$$

Section B

7. (a) State two sources of electricity. (2)

(b) Describe the characteristic of the atomic structure of conductors that makes them good conductors of electricity and give TWO examples. (3)

(c) Describe the characteristic of the atomic structure of insulators that makes them bad conductors of electricity and give TWO examples. (3)

a) either:

magnetic induction, found in turbine generators, in traditional fossil fuel power stations, and wind turbines.

Photovoltaic, found in solar panels

Chemical (reaction), found in batteries.

OR

solar, wind, nuclear, hydroelectric,

b) Good conductors have giant lattice structures, and valence electrons. this allows the electrons to pass freely through the whole material, which is current flow.

copper, and gold are both good conductors of electricity.

c) Insulators do not have giant lattice structures or valence electrons. PVC and rubber are good examples. The molecules are isolated, and do not connect in a giant lattice structure, this means each molecule is effectively isolated, preventing the free flow of electrons through the material.

8. For the circuit shown in FIG Q8 which has a battery e.m.f. of 24 V.

Determine EACH of the following:

(a) the battery terminal voltage; (4)

(b) the current at points 3, 2 and 1 in the circuit. (4)

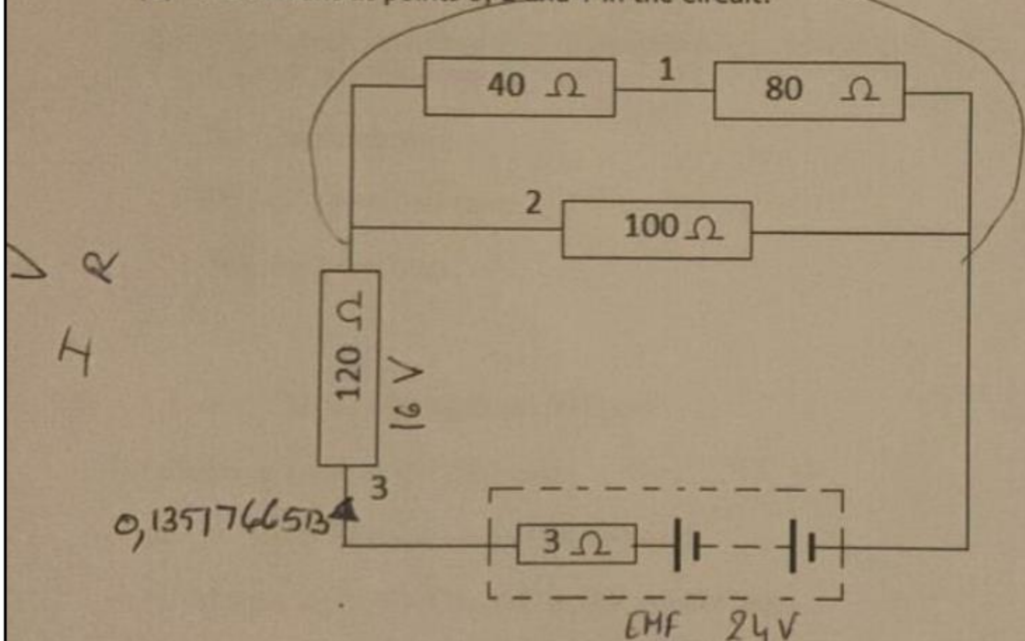
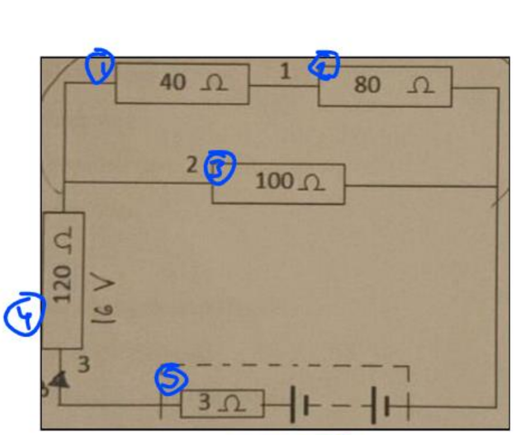


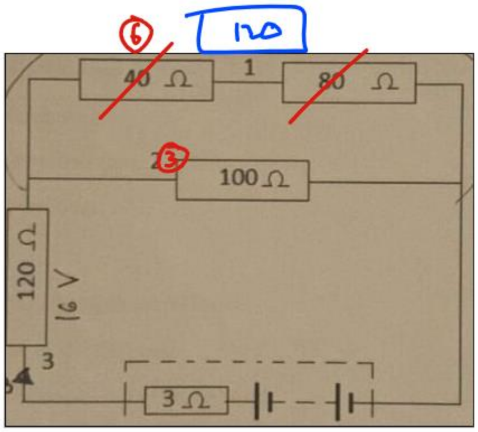
FIG Q8

a)



Res over ① ② (series)

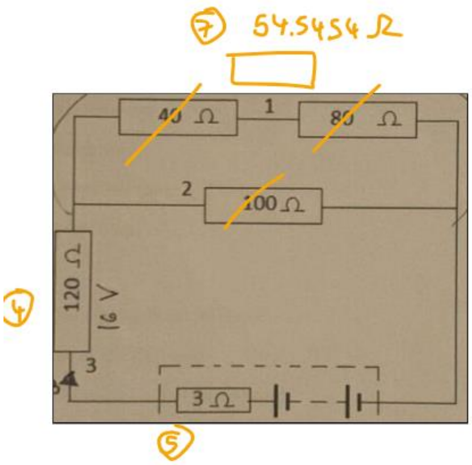
$R_T = 40 + 80 = 120$



Res over Parallel section ⑥, ③

$\frac{1}{R_T} = \frac{1}{120} + \frac{1}{100}$

$R_T = 54.5454\ \Omega$



Res over Series Section ④ ⑤ ⑦

$R_T = 54.5454 + 120 + 3 = 177.5454\ \Omega$

Circuit

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

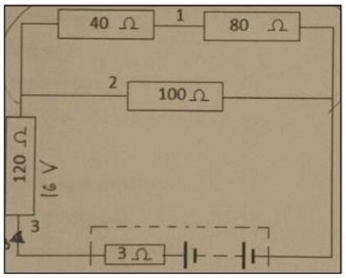
$V = 24$

$I = 0.1351766$ Amps

$R = 177.545454\ \Omega$

Voltage drop over internal res

a)

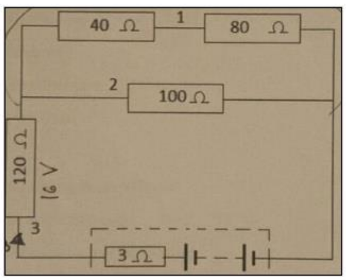


Emf − Ir = terminal Voltage

24 − 0.1351766 × 3 = 23.59447 Volts

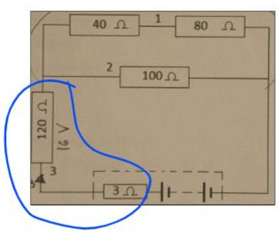
b)

currents at 1,2 and 3



current at point 3 = 0.1351766 Amps

supply voltage to the parrallel section



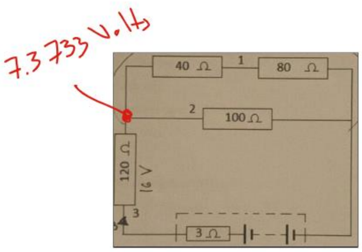
Voltage drop over 120 and 3 Ω Resistor

V = 16.6267 v
I = 0.1351766
R = 123

V = I × R

V = 16.6267 Volts

Supply Voltage to parallel section 24 − 16.6267 = 7.3733



how does the current split over the two sections in the parrallel section?

Point 1

V = 7.3733
I = 0.061444 Amps
R = 120

Point 2

V = 7.3733
I = 0.073733 Amps
R = 100

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

9. (a) State what is 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)

Primary cells are non rechargable. made from a non reversible chemical reaction.

Secondary cells are rechargable, made from a revisble chemical reaction.

10. (a) State Lenz's Law. (2)

(b) A conductor with an effective length of 500 mm creates a magnetic flux of 280 μWb when carrying a current of 45 A at right angles to a magnetic field.

The force on the conductor is 40 N.

Calculate the diameter of the conductor. (6)

Lenzs law states that the direction of the induced current will be in the opposite direction to the magnetic field doing the inducing!

b) $F = BIL\sin\theta$

$L = 0.5\,m$

$I = 45$

$F = 40$

$B = x$

$40 = x \cdot 45 \cdot 0.5$

$\frac{40}{45 \times 0.5} = x = 1.77778$ Tesla

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

$1.7777 = \frac{280 \times 10^{-6}}{A}$

$A = \frac{280 \times 10^{-6}}{1.7777}$

$\pi r^2 = 1.575 \times 10^{-4}$

$r = 7.0805 \times 10^{-3}\,m$

$d = 0.014161\,m$

11. A barge is in dry dock as shown in FIG Q11. The dry dock is rectangular with a length of 70 m and a breadth of 30 m. The dry dock is flooded and the barge, which has a beam of 20 m and a length of 62 m, just floats off the blocks when the water depth is 4.4 m. The ~~barge displaces~~ dock is filled with 6234 m^3 of seawater of relative density 1.025.

Determine EACH of the following:

(a) the mass of the barge; (5)

(b) the pressure on the bottom of the hull plating. Assume the barge to be a rectangular box barge. (3)

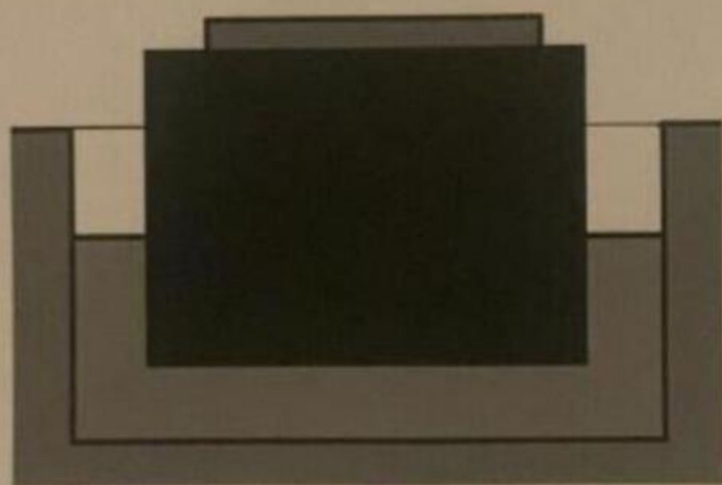
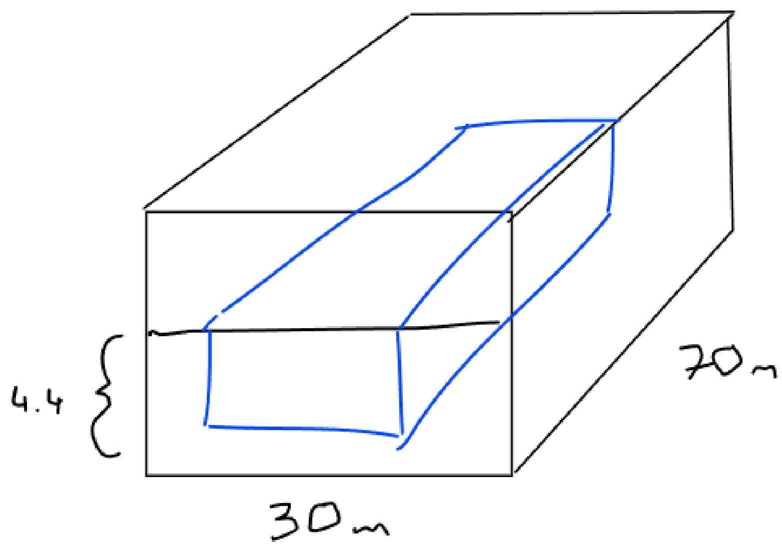


FIG Q11



Vol of water + barge = $4.4 \times 30 \times 70 = 9240\,m^3$

Ship = $9240 - 6234 = 3006\,m^3$

Mass of ship = 3006×1.025
= $3081.15\,t$

12. A vessel has a displacement volume of 19000 m^3 in sea water. It has a rectangular fuel tank 10 m long, 8 m wide and 4 m deep. The tank 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.

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

Note: the relative density of sea water is 1.025

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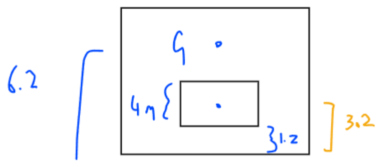
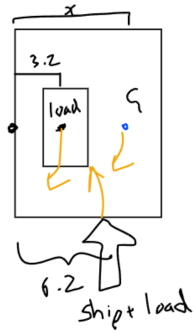


Taking moments about K



Name	Mass	Forces	Distance	Moments	Dir
Ship	19187		x	19187x	C
load	288		3.2	921.6	C
Ship+load	19475		6.2	120745	A

sum of clockwise moments = sum of anticlockwise moments

$19187x + 921.6 = 120745$

$x = 6.245$ m

this is the KG of the ship when empty

Mass ship+load = 19000 × 1.025 = 19475 t

Mass load = vol × density

10 × 4 × 8 × 0.9 = 288 t