GOA COLLEGE OF ENGINEERING

"Bhausaheb Bandodkar Technical Education Complex"
FARMAGUDI- 403 401 GOA.

CERTIFICATE

Roll No. ______ University Seat No. ______

This is to Certify that ~~Shri~~/Kum. Grace Keisam ______ of the First Semester of four years Degree Course in ______ Engineering has completed the term work in the subject ______ within the four walls of **GOA COLLEGE OF ENGINEERING, FARMAGUDI** during the year.

Lecture In-charge | Head of the Dept. | Principal

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1	To investigate First Law of Thermodynamics using Diesel Engine	19-9-25		
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1	ASSIGNMENT NO. 1	21-9-25		

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ENGIENE SPECIFICATIONS :

Four stoke four cylinder Diesel engine. The engine works on diesel.

Bore : 73.0 mm

Stroke : 88.9 mm

Compression ratio : 23 : 1

OBSERVATION & CALCULATION TABLE :

Sr. No.	Load L (kg)	Engine Speed N (RPM)	Fuel flow t (sec/10ml)	Brake Power Output Power (kW)	Heat Input to the engine (kW)	Energy Lost	Brake thermal on First Law Efficiency (%)
1	2.4	1527	32.45	0.697	5.21	4.51	13.7
2	3.4	1521	28.15	0.982	6.19	5.21	15.9
3	5.4	1512	23.5	1.55	7.42	5.87	20.9
4	8.1	1503	19.95	2.31	8.74	6.43	26.4
5	9.7	1486	23.40	2.74	7.44	4.70	36.8
6	11.4	1488	22.23	3.20	7.84	4.67	40.81

PROCEDURE FOR CALCULATIONS

1. Brake Power (kW) = $2\pi NL * 9.81 / 60000$
2. Fuel = 5ml

density of diesel = 830 kg/m^3

density = mass / volume

Mass flow rate = $10 \cdot 10^{-6} \cdot 840 / t$ kg/s

3. Heat Input = mass flow rate x calorific value (kW)

Calorific value = 42000 kJ/kg

4. Brake Thermal Efficiency (%) = $\frac{\text{Brake Power}}{\text{Heat Input}} \times 100$

5. Energy lost (kW) = HI - BP

GRAPHS : 1. Load v/s BTE

CALCULATIONS :

① $BP = \frac{2\pi NT}{60}$ $T = 2.4 \times 9.81 \times 10^{-3} \times 0.185$

$= 4.36 \times 10^{-3}$

$= \frac{2 \times 3.14 \times 0.00436 \times 1527}{60}$ $= 0.00436$ kNm

$= 0.697$ kW $EL = HI - BP$

$= 5.21 - 0.697$

$HI = m_f \times C_v$ $= 4.51$ kW

$= V_f \times \rho_f \times C_v$

$= \frac{5 \times 10^{-3} \times 10^{-3}}{33.45} \times 830 \times 42000$

$= 5.21$ kW

$\eta_1 = \frac{BP}{HI} \times 100 = \frac{0.697}{5.21} \times 100 = 0.137 \times 100 = 13.7\%$

② $BP = \frac{2\pi NT}{60}$ $T = 3.4 \times 9.81 \times 10^{-3} \times 0.185$

$= 0.00617$ KNm

$= \frac{2 \times 3.14 \times 0.00617 \times 1521}{60}$ $EL = HI - BP$

$= 0.982$ kW $= 6.19 - 0.982$

$= 5.21$

$HI = V_f \times \rho_f \times C_v$

$= \frac{5 \times 10^{-3} \times 10^{-3}}{28.15} \times 830 \times 42000$

$= 6.19$ kW

$\eta_1 = \frac{BP}{HI} \times 100 = \frac{0.982}{6.19} \times 100 = 15.9\%$

③ $BP = \frac{2\pi NT}{60}$ $\quad T = 5.4 \times 9.81 \times 10^{-3} \times 0.185$

$= 0.0098\ kNm$

$= \frac{2 \times 3.14 \times 0.0098 \times 1512}{60}$ $\quad EL = HI - BP \approx 5.87$

$= 1.55\ kw$

$\eta_1 = \frac{BP}{HI} \times 100$

$HI = V_f \times S_f \times C_v$

$= \frac{5 \times 10^{-3} \times 10^{-3}}{23.5} \times 830 \times 42000$ $\quad = \frac{1.55}{7.42} \times 100$

$= 7.42\ kw$ $\quad = 20.9\ \%$

④ $BP = \frac{2\pi NT}{60} = \frac{2 \times 3.14 \times 1503 \times 8.1 \times 9.81 \times 10^{-3} \times 0.185}{60} = 2.31\ kW$

$HI = V_f \times S_f \times C_v = \frac{5 \times 10^{-6}}{19.95} \times 830 \times 42000 = 8.74\ kW$

$EL = HI - BP = 8.74 - 2.31 = 6.43$

$\eta_1 = \frac{BP}{HI} \times 100 = \frac{2.31}{8.74} \times 100 \doteq 26.4\ \%$

⑤ $BP = \frac{2\pi NT}{60} = \frac{2 \times 3.14 \times 1486 \times 9.7 \times 9.81 \times 10^{-3} \times 0.185}{60} = 2.74\ kW$

$HI = V_f \times S_f \times C_v = \frac{5 \times 10^{-6}}{23.40} \times 830 \times 42000 = 7.44\ kW$

$EL = HI - BP = 7.44 - 2.74 = 4.70$

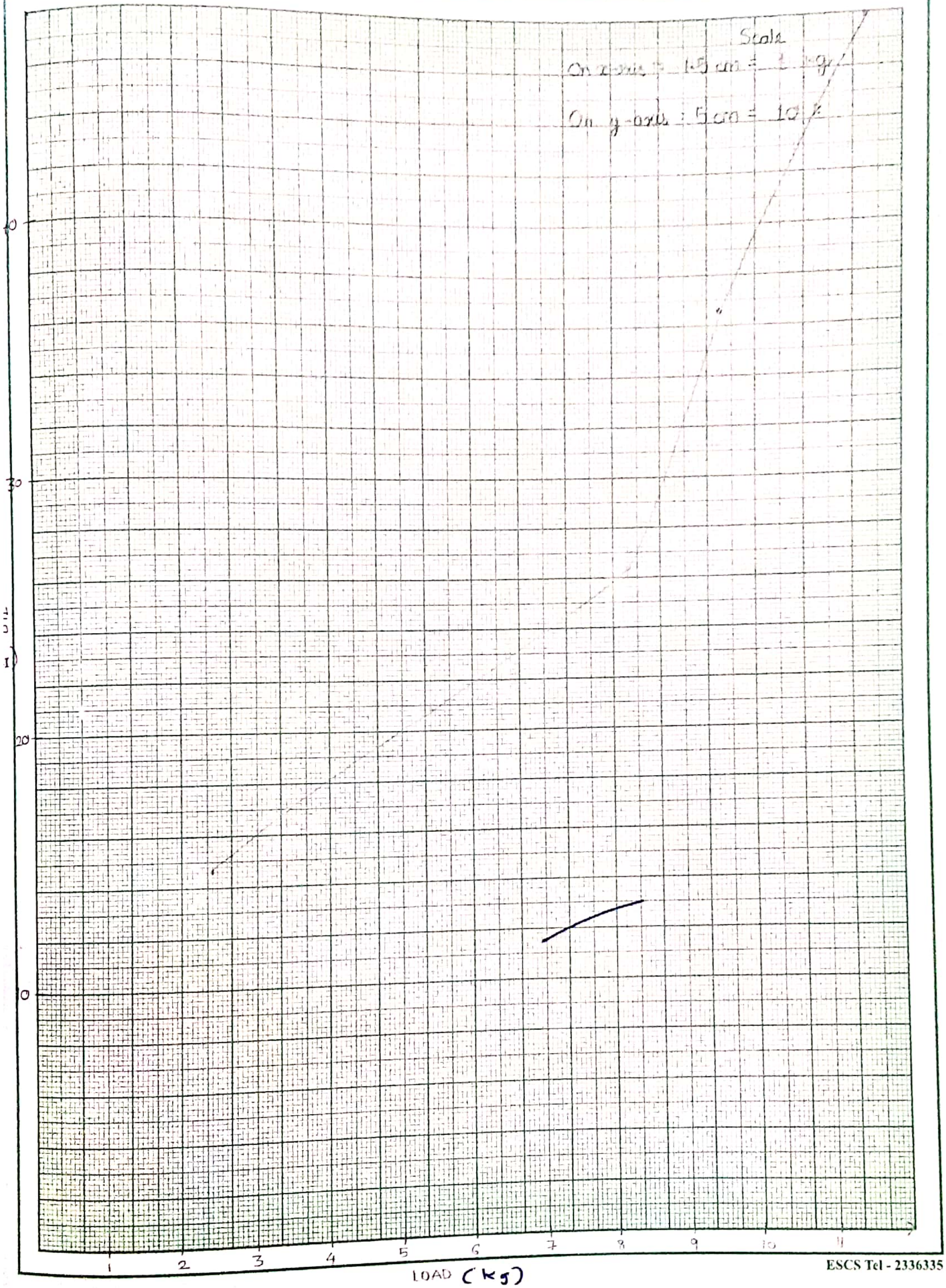
$\eta_1 = \frac{BP}{HI} \times 100 = 36.8\ \%$

⑥ $BP = \frac{2\pi NT}{60} = \frac{2 \times 3.14 \times 1488 \times 11.4 \times 10^{-3} \times 9.81 \times 0.185}{60} = 3.20\ kW$

$HI = V_f \times S_f \times C_v = 0.22 \times 10^{-6} \times 830 \times 42000 = 7.84\ kW$

$EL = HI - BP = 4.67\ kW$

$\eta_1 = 40.81\ \%$


Scale
On x-axis : 1.5 cm = 1 kg
On y-axis : 5 cm = 10 %
40
30
20
10
1
2
3
4
5
6
7
8
9
10
11
LOAD (kg)

RESULT

Diesel engine is analysed for First law of Thermodynamics by
(i) Energy balance
(ii) Calculations of First law Efficiency

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Vy Good

02/10/2017

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OBSERVATION & CALCULATION TABLE :

Sr. No.	Load (kg)	Engine speed (RPM)	Brake Power Output power (kW)	Heat input to the engine (kW)	Energy lost (kW)	Brake thermal or First law efficiency (%)
1	2.3	1527	0.697	5.21	4.51	13.7
2	3.4	1521	0.982	6.19	5.21	15.9
3	5.4	1512	1.55	7.42	5.87	20.9
4	8.1	1503	2.31	8.74	6.43	26.4
5	9.7	1486	2.74	7.44	4.70	36.8
6	11.4	1488	3.20	7.84	4.67	40.81

① $\eta_I = \frac{BP}{HI} \times 100 = \frac{0.697}{5.21} \times 100 = 13.7\%$

② $\eta_I = \frac{BP}{HI} \times 100 = \frac{0.982}{6.19} \times 100 = 15.9\%$

③ $\eta_I = \frac{BP}{HI} \times 100 = \frac{1.55}{7.42} \times 100 = 20.9\%$

④ $\eta_I = \frac{BP}{HI} \times 100 = \frac{2.31}{8.74} \times 100 = 26.4\%$

⑤ $\eta_I = \frac{BP}{HI} \times 100 = \frac{2.74}{7.44} \times 100 = 36.8\%$

⑥ $\eta_I = \frac{BP}{HI} \times 100 = \frac{3.2}{7.84} \times 100 = 40.81\%$

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OBSERVATION & CALCULATION TABLE :

Sr No.	Load (kg)	Maximum Temperature (T_H) K	Minimum Temperature T_L (K)	Carnot Efficiency η_{carnot} (%)	First law Efficiency η_I (%)	Second Efficiency η_{II} (%)
1	2.4				13.7	15.9
2	3.4				15.9	18.5
3	5.4	2000 K	300 K	86 %	20.9	24.3
4	8.1				26.4	30.7
5	9.7				36.8	42.8
6	11.4				40.81	47.45

① $\eta_{II} = \frac{\eta_I}{\eta_{carnot}} \times 100 = \frac{13.7}{86} \times 100 = 15.9\ \%$

② $\eta_{II} = \frac{\eta_I}{\eta_{carnot}} \times 100 = \frac{15.9}{86} \times 100 = 18.5\ \%$

③ $\eta_{II} = \frac{\eta_I}{\eta_{carnot}} \times 100 = \frac{20.9}{86} \times 100 = 24.3\%$

④ $\eta_{II} = \frac{\eta_I}{\eta_{carnot}} \times 100 = \frac{26.4}{86} \times 100 = 30.7\ \%$

⑤ $\eta_{II} = \frac{\eta_I}{\eta_{carnot}} \times 100 = \frac{36.8}{84} \times 100 = 42.8\%$

⑥ $\eta_{II} = \frac{\eta_I}{\eta_{carnot}} \times 100 = \frac{40.81}{86} \times 100 = 47.45\ \%$

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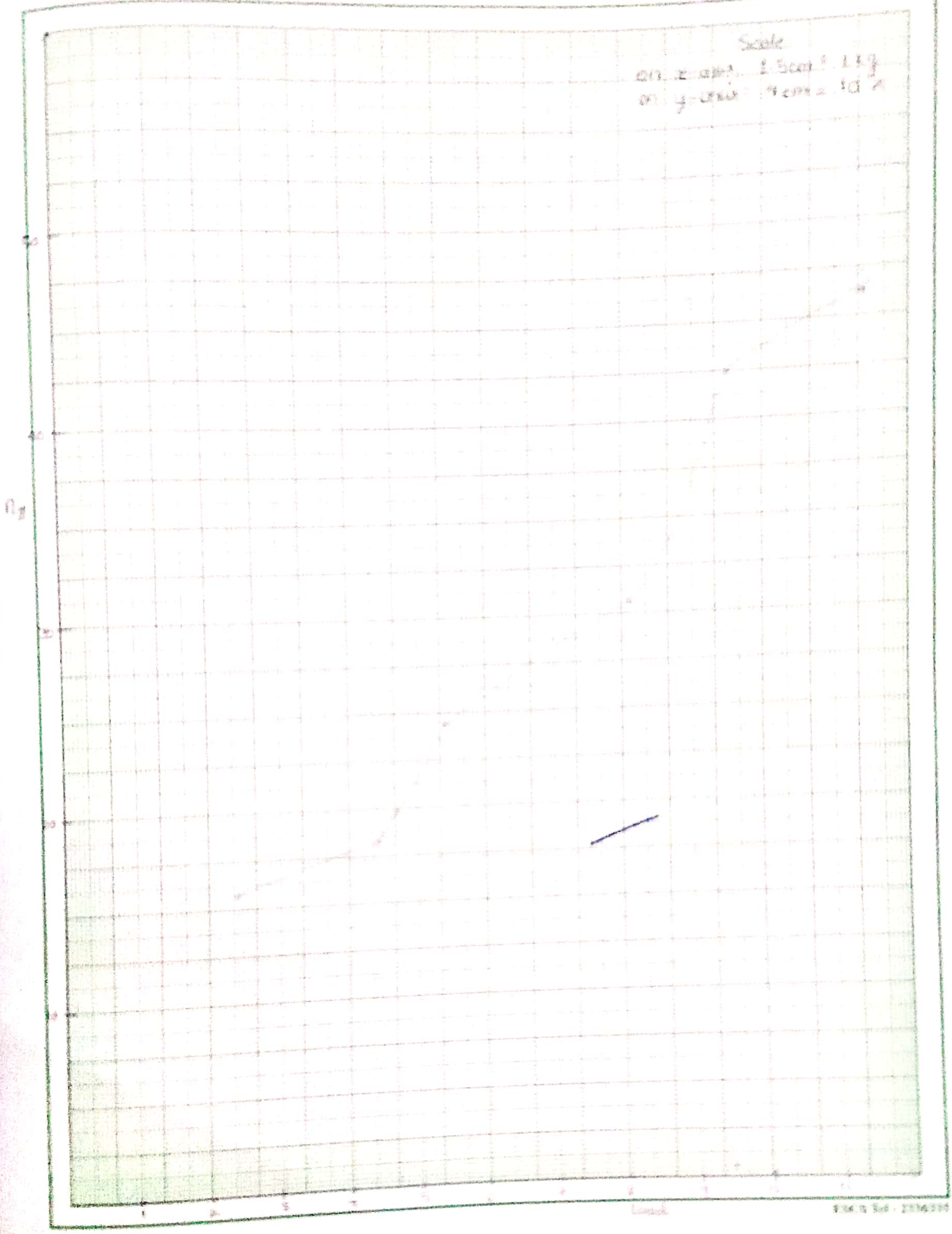

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RESULT :

Diesel Engine is analysed for Second law of thermodynamics by

(i) Calculations of Carnot Efficiency

(ii) Calculations of First law Efficiency

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1. What is thermodynamic system, and how is it different from its surroundings?

→ A thermodynamic system is a quantity of matter or a region in space chosen for study.

It is a quantity of matter or region in space while surroundings is the mass or region outside the system.

2. What are the three types of thermodynamic systems & how do they differ in terms of mass & energy transfer? Give examples of each type of system

→ The 3 types of thermodynamic systems are:

a) Closed system

b) Open system

c) Isolated system

CLOSED SYSTEM	OPEN SYSTEM	ISOLATED SYSTEM
• consists of fixed amount of mass	• mass can enter or leave this system	• Mass cannot enter or leave this system
• no mass can enter or leave this system.	• energy can enter or leave this system	• Energy cannot enter or leave this system
• ~~Eg~~ energy can enter or leave this system		
Eg. Pressure cooker	• Eg. Boiler, turbine	• Eg. thermos flask

3. What are the intensive properties & extensive properties? Give examples.

→ Intensive : Independent on mass of system

Eg. velocity, elevation

Extensive : Dependent on mass of system

Eg. Pressure, density

4. Distinguish between the terms 'change of state', 'path' & 'process'.

→ Any change that a system undergoes from one equilibrium to another is a process while the series of states through which a system passes during the process is called path of the process.

5. What is a reversible process in thermodynamics?

→ A reversible process in thermodynamics is an ideal process that can be reversed at any stage, so that both the system & surroundings return exactly to their initial states without leaving any change in the universe

6. How is work defined in thermodynamics & what are some examples of work done by or on a system?

→ The work in thermodynamics is the energy transferred when a force moves the boundary of a system.

- Work is said to be done by a system if the sole effect on things external to the system can be reduced to the raising of a weight.
Eg. When a gas expands in a piston-cylinder arrangement, it pushes the piston upward & does work on the surrounding.
- Work is said to be done on a system if the sole effect on things external to the system can be reduced to the lowering of a weight.
Eg. When a piston is pushed downward on a gas cylinder, the surroundings compress the gas. The gas volume decreases, & work is done on the system by the surroundings

7. What are the different thermodynamic processes? Derive an equation for work transfer during reversible isothermal process.

→ 1. Isothermal (temp const)
2. Isobaric (pressure const)
3. Isochoric (volume const)
4. Adiabatic ($Q=0$)

$$W = \int_{V_1}^{V_2} P\,dv$$

$$W = \int_{V_1}^{V_2} \frac{nRT}{V}\,dv = nRT \int_{V_1}^{V_2} \frac{dV}{V} = nRT \ln \frac{V_2}{V_1}$$

Using $P_1V_1 = P_2V_2$

$$W = nRT \ln \frac{P_1}{P_2}$$

8. Derive an equation for work transfer during reversible adiabatic process.

Given: Reversible adiabatic $\Rightarrow$ $\delta Q = 0$ & $PV^{\gamma} = \text{const}$ $\left(\gamma = \frac{C_p}{C_v}\right)$

First law: $\delta Q = dU + \delta W$

$0 = dU + Pdv$

$\delta dW = -du$

$W_{1\to2} = \int_1^2 \delta W$

$= -\int_1^2 dU$

$= U_1 - U_2$

For an ideal gas, $U = mC_vT$

$W_{1\to2} = mC_v(T_1 - T_2)$

Using $C_p - C_v = R$ & $\gamma = \frac{C_p}{C_v}$

$C_v = \frac{R}{\gamma - 1}$

$W_{1\to2} = \frac{mR}{\gamma-1}(T_1 - T_2)$

9. State the First Law of Thermodynamics & prove that for a non-flow process, it leads to the energy equation $Q = \Delta U + W$.

→ The First law of thermodynamics states that energy can neither be created nor destroyed; it can only be transformed from one form to another & the total energy of an isolated system remains constant.

10. What is the difference between heat & work as forms of energy transfer?

→

Heat	Work
• It is the energy transfer due to a temperature difference between system & surroundings.	• It is the energy transfer that occurs when a force moves the boundary of the system.
• Heat flows from high to low temperature.	• Work can be done by the system or on the system.

11. Explain the concept of enthalpy & its relationship to heat & work in a constant pressure process.

→ Enthalpy (H) is a thermodynamic property defined as: $H = U + PV$

It represents the total heat content of a system.

$\delta Q = dU + \delta W$ (when pressure is const: $\delta W = P\,dV$)

$\delta Q = dU + P\,dV$

But,

$dH = d(U + PV) = dU + P\,dV + V\,dP$

$dH = dU + P\,dV$

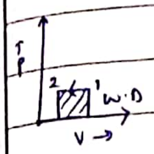
So,

$\delta Q_p = dH$

Hence at constant pressure, the heat transfer to the system equals the change in enthalpy.

PROBLEMS :

1. A stationary mass of gas is compressed without friction from the initial state of volume $0.3 m^3$ & pressure of 0.105 MPa to a final volume of $0.15 m^3$ & pressure of 0.105 MPa. Calculate the work required to be done to achieve this compression. Show the process on the Pressure-volume diagram



$V_1 = 0.3 m^3$

$P_2 = P_1 = 0.105 MPa$

$V_2 = 0.15 m^3$

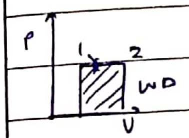
$W_{1-2} = P(V_2 - V_1)$

$= 0.105 \times 10^6 (0.15 - 0.3)$

$= -15.75 kJ$

∴ work done is -ve because work is done on system for compression.

2. A stationary mass of gas is expanded without friction from the initial state of volume $0.15 m^3$ & pressure 0.105 MPa to a final volume of $0.3 m^3$ & pressure of 0.105 MPa. Calculate the work done. Show the process on the PV diagram.



$V_1 = 0.15 m^3$

$P_2 = P_1 = 0.105 MPa$

$V_2 = 0.3 m^3$

$W_{1-2} = P(V_2 - V_1)$

$= 0.105 \times 10^6$

$= 15.75 kJ$

∴ The system does work so work done is positive.

3. A stationary mass of gas is expanded isothermally without friction from the initial state of volume $0.1 m^3$ & pressure of 0.105 MPa to a final volume of $0.4 m^3$. Find the final pressure. Also, calculate the work done & the heat transferred. Show the process on the PV diagram.

$PV = C$

$P_1 V_1 = P_2 V_2$

$P_1 = 0.105 MPa$

$V_1 = 0.15 m^3$

$V_2 = 0.3 m^3$

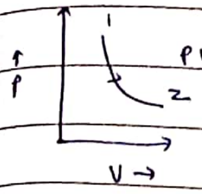
$P_1 V_1 = P_2 V_2$

$0.105 \times 10^6 \times 0.15 = P_2 \times 0.3$

$P_2 = \frac{0.105 \times 10^6 \times 0.15}{0.3}$

$= 52500 \text{ Pa}$

$= 0.0525 \text{ Pa}$



W.D for isothermal process : $W_{1-2} = P_1 V_1 \log \frac{V_2}{V_1} = 0.105 \times 10^6 \times 0.15 \log \frac{0.3}{0.15}$

$= 4.741 \text{ kJ}$

4. A stationary mass of gas is expanded by a reversible adiabatic process from the initial state of volume 0.1 m3 & pressure of 0.105 MPa to a final vol of 0.4 m3. Find the final pressure. Take $\gamma = 1.4$. Also, calculate the work done & the heat transferred. Show it on diagram.

$P_1 = 0.105$ MPa

$V_1 = 0.1 \text{ m}^3$

$V_2 = 0.4 \text{ m}^3$

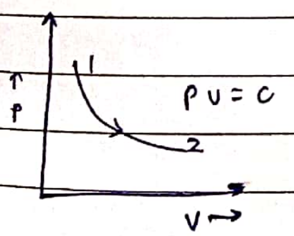
$\gamma = 1.4$

$P_1 V_1^\gamma = P_2 V_2^\gamma$

$0.105 \times 10^6 \times 0.1^{1.4} = P_2 \times 0.4^{1.4}$

$P_2 = \frac{0.105 \times 10^6 \times 0.1^{1.4}}{0.4^{1.4}}$

$= 0.015$ MPa



for Reversible adiabatic

$Q_{1-2} = 0$

$W_{1-2} = \frac{P_1 V_1 - P_2 V_2}{\gamma - 1} = \frac{0.105 \times 10^6 \times 0.1 - 0.015 \times 10^6 \times 0.4}{1.4 - 1}$

$= 11250 \text{ J}$

$= 11.25 \text{ kJ}$

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