KSU CET

S1 & S2 Notes

2019 Scheme

KSU CET

Manifest the leadership in you

MODULE 1

THERMODYNAMICS

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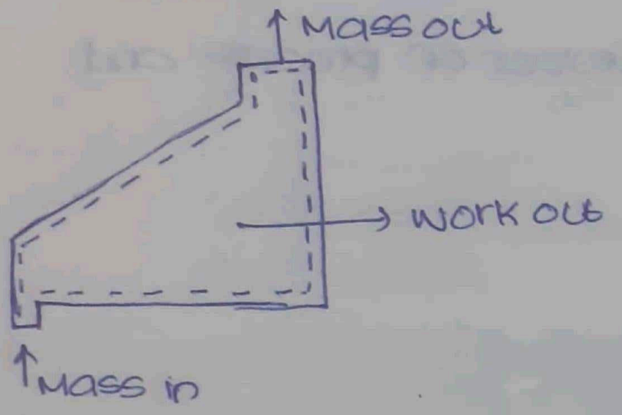
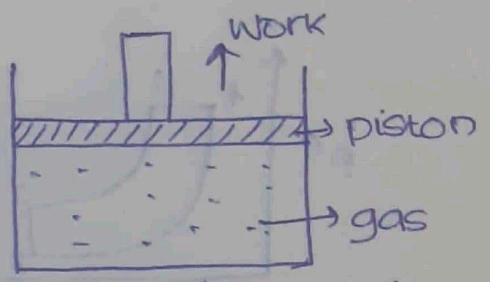
system — * open
* closed
* Isolated.

system → surroundings.
↓
Boundary

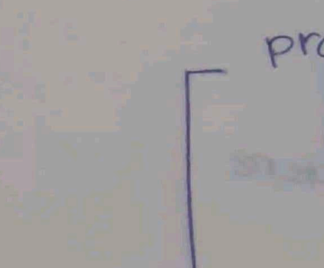




cylindrical (closed)

STATE

represented as a point in a graph ploted b/w two thermodynamic quantity.

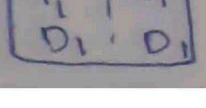


path function:- work of heat
depends on area under work.

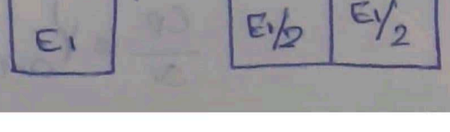
property → state function.

pressure
volume

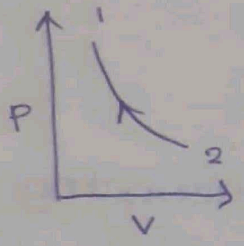
Intensive.

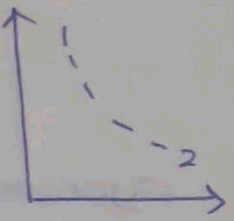


Extensive



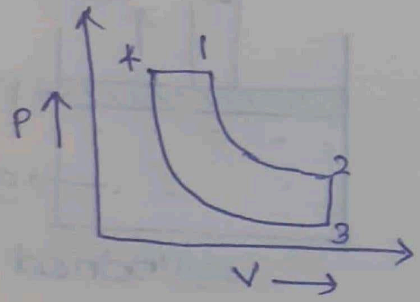
If a system changes from one state to another. It is a proce





path: - If a system passes through a series of states.

cycle: - If a system undergoes a number of process and come back to initial state.



Ideal gas equation ⟶ Boyles law $(V \propto 1/P)$ + Charles law $(V \propto T)$.

$PV = mRT$ → absolute Temp.

R = 287 J/kg, characteristic gas constant

R_u = universal gas constant
= R×M
= 8314 J/kmol

Heat - form energy

heat transfer:

heat accepted (Q +ve)   heat rejected (Q -ve)

specific heat : 1 kg gas → 1°C raise temperature

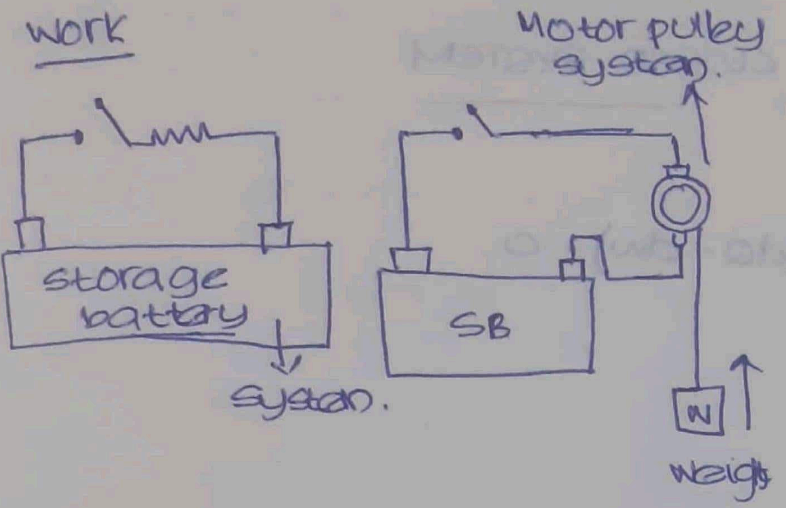
$C_p(\text{air}) = 1.005$ kJ/kgK.

$C_v(\text{air}) = 0.718$ kJ/kgK

$R = C_p - C_v$

$$\frac{C_p}{C_v} = \gamma_{air} = 1.4$$

Work



Resistor heated up.

Side effect external to the system can be reduced to lifting of a weight.

energy transfer b/w the boundary of a system other than temperature difference.

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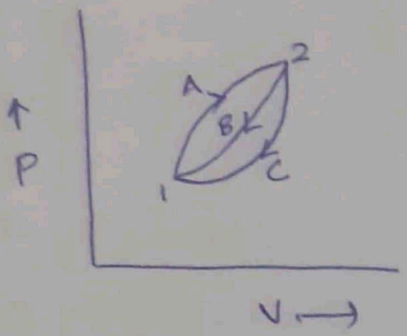
APPLICATION OF FIRST LAW TO A CLOSED SYSTEM



$$\oint (dQ - dW) = 0$$

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cycle 1-A, 2.B-1

applying first law.

$$\int_{1-A}^{2} (dQ-dW) + \int_{2-B}^{1} (dQ-dW) = 0 \quad \text{——— (1)}.$$

cycle 1-A, 2.C-1

$$\int_{1-A}^{2} (dQ-dW) + \int_{2-C}^{1} (dQ-dW) = 0 \quad \text{——— (2)}$$

From (1) and (2).

$$\int_{2-B}^{1} (dQ-dW) = \int_{2-C}^{1} (dQ-dW)$$

NOTE :-

$$\int dQ - dW = E_2 - E_1$$

(change of energy).

$$\boxed{Q_{1-2} - W_{1-2} = \Delta E}$$

Total energy of a system, E = KE + PE + $\overset{(U)}{\text{internal energy}}$

For a stationary closed system undergoing a process.

$\Delta KE = 0$, $\Delta PE = 0$

$\Delta E = \Delta U$.

$$\therefore \boxed{Q_{1-2} - W_{1-2} = \Delta U}$$

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According to Joule's law

$\Delta U \propto \Delta T$

$\Delta U = mC \cdot \Delta T$

C - specific heat
m - mass

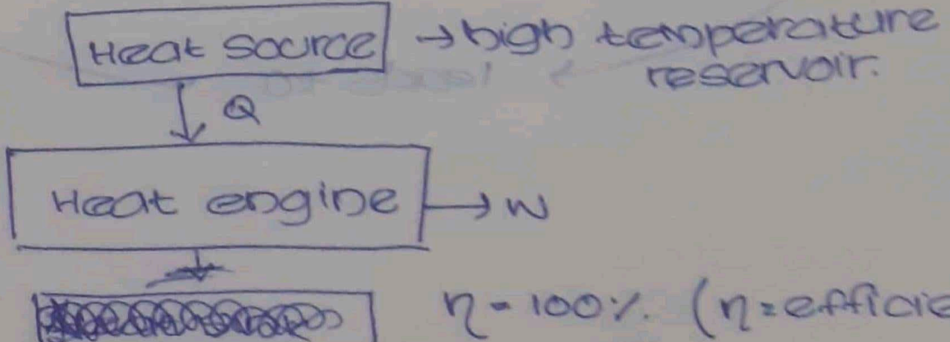
$$\boxed{\Delta U = mC_v \Delta T}$$

SECOND LAW OF THERMODYNAMICS

Restriction for convertion of energy.

1 → Kelvin-planck statement
2 → clausius statement

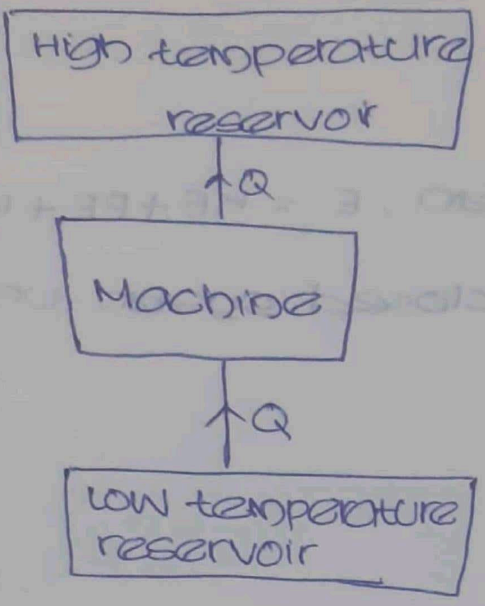
According to this statement



→ high temperature reservoir.

$\eta = 100\%$. (η = efficiency)

it is impossible.

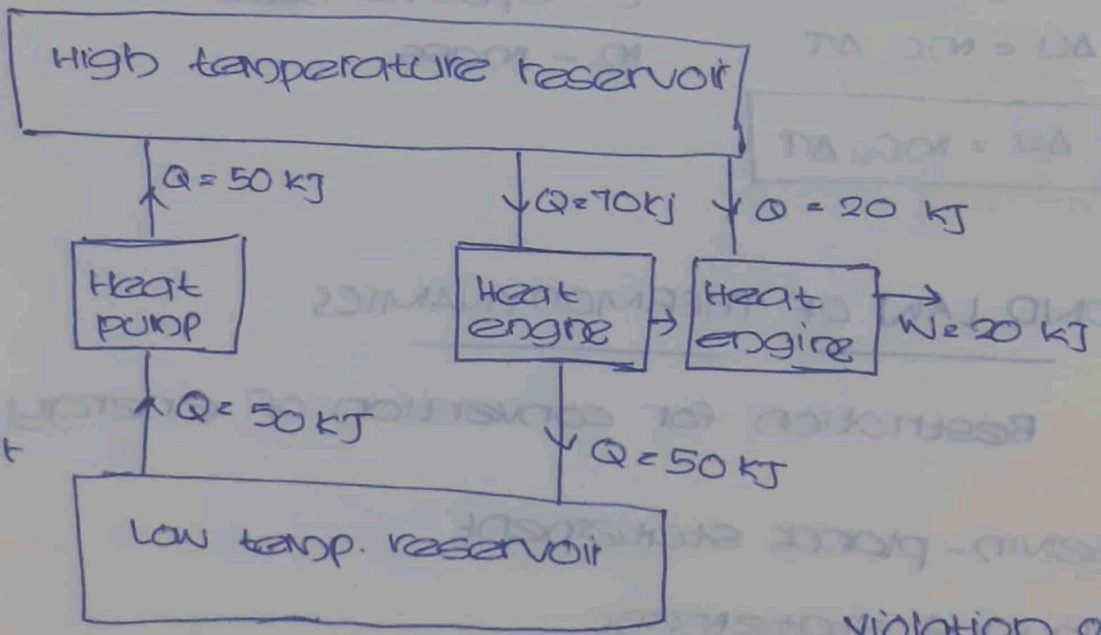


If we apply a work
to machine
then it is possible

it is impossible

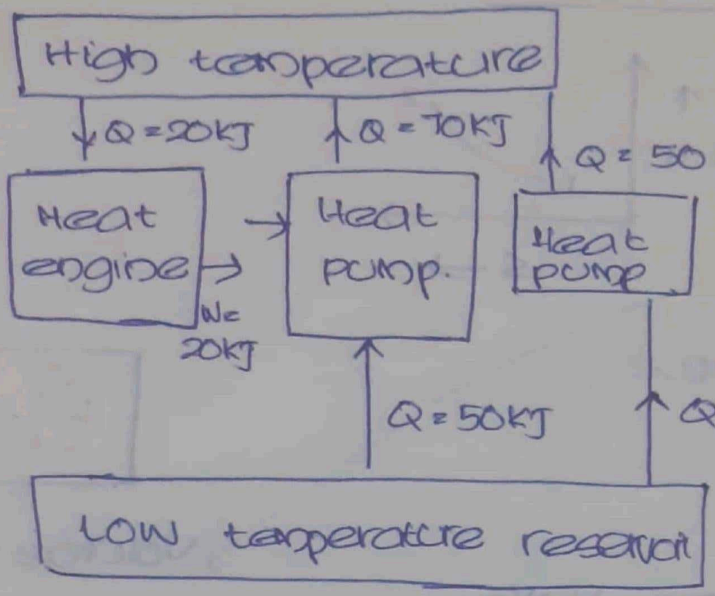
EQUIVALENCE OF KELVIN-PLANCK AND CLAUSES STATEMENTS

violation
of
Clausius
statement



leads to

violation of
kelvin plancks
statement.



violation of clausius statement

violation of kelvin plancks statement → leads to

THERMODYNAMIC PROCESS

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1. constant volume (isochoric process).
2. constant pressure (isobaric).
3. constant temperature (isothermal).
4. Adiabatic.
5. polytropic.

enthalpy(H) = U + PV

$H_2 - H_1 = mC_p(T_2 - T_1)$.

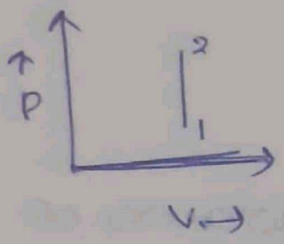
entropy - degree of randomness.

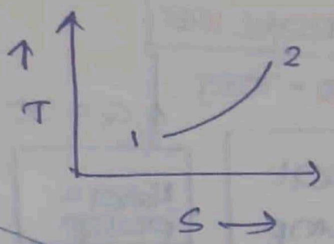
work - high grade energy.

heat - low grade energy.

change in entropy, $ds = \frac{dQ}{dt}$

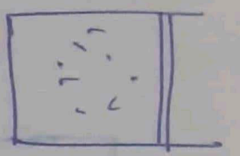
ISOCHORIC PROCESS





→ P-V-T relationship,

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$



Volume = constant

T ↑ P ↑

as T ↑ S ↑.

constant volume, $V_1 = V_2$

$$\Longrightarrow \frac{P_1}{T_1} = \frac{P_2}{T_2}$$

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

→ change in Internal energy (IE).

$$\Delta U = mC_v(T_2 - T_1).$$

→ work done.

$$W_{1-2} = \int_1^2 P.dV. \quad \text{but } dV = 0.$$

$$\Longrightarrow W_{1-2} = 0.$$

→ Heat transfer.

$$Q_{1-2} = W_{1-2} + \Delta U$$

$$= 0 + mC_v(T_2 - T_1).$$

$$= mC_v(T_2 - T_1)$$

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→ change in entropy.

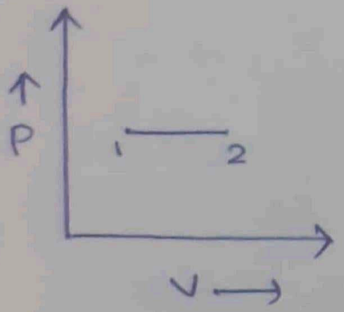
here

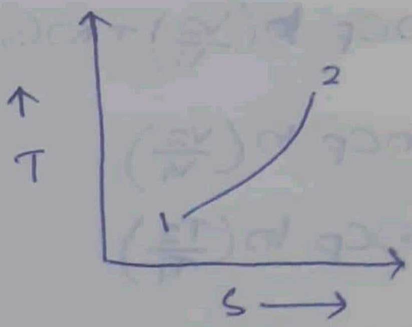
$ds = S_2 - S_1$

$= mC_v \ln\left(\frac{P_2}{P_1}\right)$

$$\boxed{\begin{aligned} ds &= mC_p \ln\left(\frac{V_2}{V_1}\right) + mC_v \ln\left(\frac{P_2}{P_1}\right) \\ ds &= mC_p \ln\left(\frac{T_2}{T_1}\right) - mR \ln\left(\frac{P_2}{P_1}\right) \\ ds &= mC_v \ln\left(\frac{T_2}{T_1}\right) + mR \ln\left(\frac{V_2}{V_1}\right). \end{aligned}}$$

ISOBARIC PROCESS





→ P-V-T relationship.

$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$

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

$\frac{V_1}{V_2} = \frac{T_1}{T_2}$ → used in diesel cycle.

→ change in I.E

$\Delta U = mC_v(T_2 - T_1)$

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→ work done.

$W_{1-2} = \int_1^2 P \cdot dV.$

$= P\left[V\right]_{V_1}^{V_2}$

$$W_{1-2} = P[V_2 - V_1]$$

$V \uparrow T \uparrow$

P = constant.

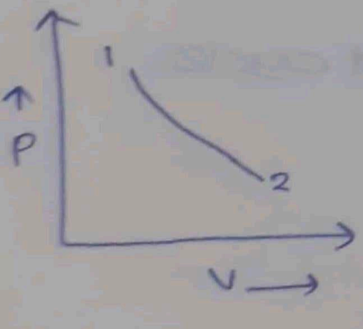
→ Heat Transfer

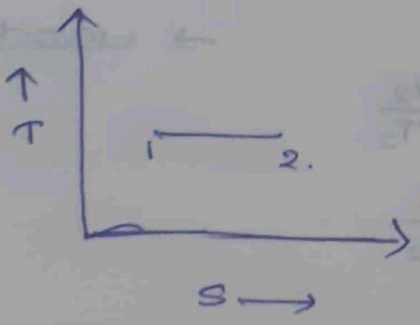
$$Q_{1-2} = W_{1-2} + \Delta U$$
$$= P[V_2 - V_1] + mC_v(T_2 - T_1)$$
$$= mR[T_2 - T_1] + mC_v(T_2 - T_1)$$
$$= m(T_2 - T_1)[R + C_v] = mC_p(T_2 - T_1)$$

→ Entropy change

$$S_2 - S_1 = mC_p \ln\left(\frac{V_2}{V_1}\right) + mC_v \underbrace{\ln\left(\frac{P_2}{P_1}\right)}_{=0}$$
$$= mC_p \ln\left(\frac{V_2}{V_1}\right)$$
$$= mC_p \ln\left(\frac{T_2}{T_1}\right)$$

ISOTHERMAL PROCESS





→ P-V-T relationship

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

$T_1 = T_2$ (constant)

$$\Longrightarrow P_1V_1 = P_2V_2.$$

→ change in I.E

$$\Delta U = m C_v (T_2 - T_1)$$

$$T_1 = T_2 \Rightarrow \Delta U = 0$$

→ work done.

$$W_{1-2} = \int_1^2 P \, dV$$

but $P_1V_1 = P_2V_2 = PV$

$$P = \frac{P_1V_1}{V}$$

$$= \int_1^2 \frac{P_1V_1}{V} dV$$

$$= P_1V_1 \int_1^2 \frac{1}{V} \cdot dv$$

$$= P_1V_1 \left[\ln v\right]_{v_1}^{V_2}$$

$$= P_1V_1 \ln\left[\frac{V_2}{V_1}\right]$$

$$= P_1V_1 \ln\left[P_1/P_2\right]$$

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→ Heat transfer

$$Q_{1-2} = W_{1-2} + \Delta U$$

$, \Delta U = 0 .$

$$= P_1V_1 \ln\left[P_1/P_2\right] , \; P_1V_1 \ln\left[\frac{V_3}{V_4}\right].$$

→ Entropy change.

$$S_2 - S_1 = mC_v \ln\left(\frac{T_2}{T_1}\right) + mR \ln\left(\frac{V_2}{V_1}\right)$$

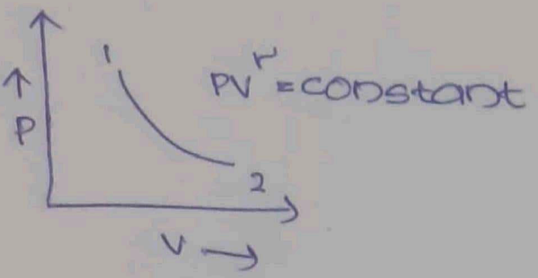
$$\downarrow$$

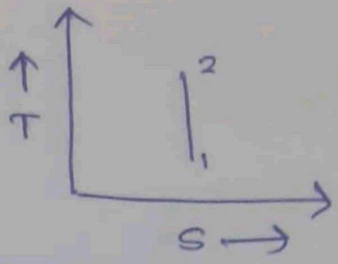
$$= 0 .$$

$$S_2 - S_1 = mR \ln\left(\frac{V_2}{V_1}\right).$$

ADIABATIC PROCESS

$\gamma = \frac{C_P}{C_V}$





→ P-V-T relationship,

$$P_1V_1^{\gamma} = P_2V_2^{\gamma} = PV^{\gamma} = \text{constant}$$

$$\frac{P_1}{P_2} = \left(\frac{V_2}{V_1}\right)^{\gamma} \quad \text{——(1)}$$

IMP

$$\frac{P_1}{P_2} = \left(\frac{T_1}{T_2}\right)^{\frac{\gamma}{\gamma-1}} \quad \text{——(2)}$$

$$\frac{V_2}{V_1} = \left(\frac{T_1}{T_2}\right)^{\frac{1}{\gamma-1}} \quad \text{——(3)}$$

$$\left[\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2} \right.$$

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

→ change in I.E

$$\Delta U = mC_V(T_2 - T_1).$$

→ work done

$$W_{1-2} = \int_1^2 P.dV$$

$$P_1V_1^{\gamma} = P_2V_2^{\gamma} = PV^{\gamma} = C$$

$$P = \frac{C}{V^{\gamma}} = CV^{-\gamma}$$

$$W_{1-2} = \int_1^2 CV^{-\gamma}.dv$$

$$= C\left[\frac{V^{-\gamma+1}}{-\gamma+1}\right]_{V_1}^{V_2}$$

$$W_{1-2} = \frac{P_2V_2 - P_1V_1}{1-\gamma} = \boxed{\frac{P_1V_1 - P_2V_2}{\gamma-1}} = \frac{mR(T_1-T_2)}{\gamma-1}$$

→ ~~entropy change~~ Heat transfer.

$Q_{1-2} = 0$

→ Entropy change

$$ds = \frac{dQ}{T}$$

$dQ>0 \Longrightarrow ds = 0.$

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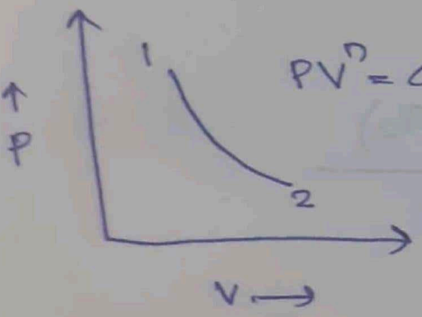
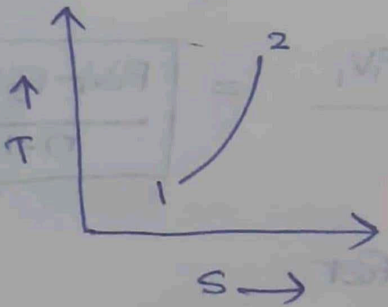
POLYTROPIC PROCESS



PV^n = a constant.



→ P-V-T relationship.

$$P_1V_1^n = P_2V_2^n = PV^n = \text{a constant}$$

$$\frac{P_1}{P_2} = \left(\frac{V_2}{V_1}\right)^n \text{ —— (1)}$$

$$\frac{P_1}{P_2} = \left(\frac{T_1}{T_2}\right)^{\frac{n}{n-1}} \longrightarrow (2)$$

$$\frac{V_2}{V_1} = \left(\frac{T_1}{T_2}\right)^{\frac{1}{n-1}} \text{ —— (3)}$$

→ change in I.E

$$\Delta U = nC_v (T_2 - T_1).$$

→ work done

$$W_{1-2} = \int_1^2 P.dv$$

$$P_1V_1^n = P_2V_2^n = PV^n = C$$

$$P = \frac{C}{V^n} = CV^{-n}$$

$$W_{1-2} = \int_1^2 CV^{-n}.dV$$

$$= C\left[\frac{V^{-n+1}}{-n+1}\right]_{V_1}^{V_2}$$

$$W_{1-2} = \frac{P_2V_2 - P_1V_1}{1-n} = \boxed{\frac{P_1V_1 - P_2V_2}{n-1}} = \frac{nR(T_1 - T_2)}{n-1}$$

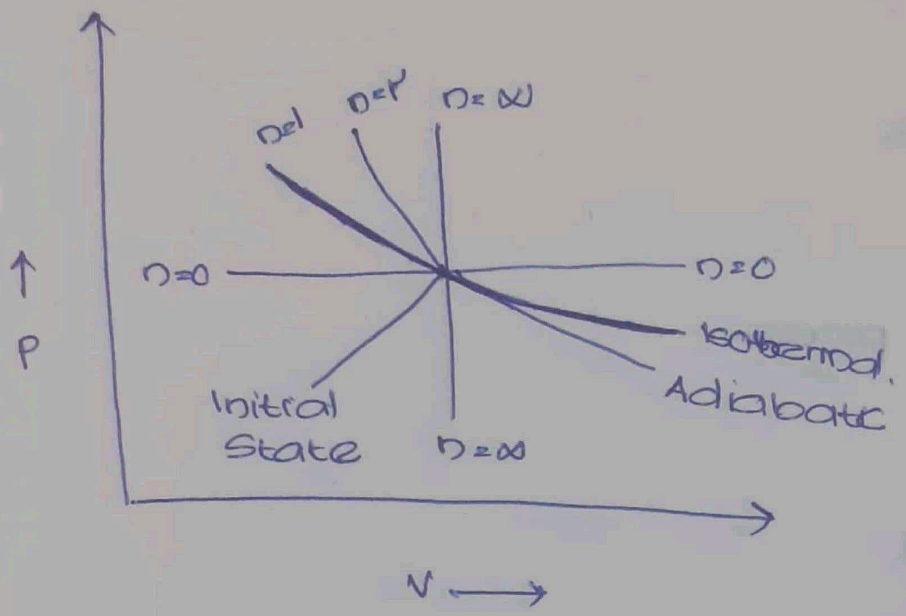
→ Heat transfer.

$$Q_{1-2} = W_{1-2} + \Delta U$$

$$= \frac{\gamma - n}{\gamma - 1} W_{1-2}.$$

→ Entropy change

$$S_2 - S_1 = n\,\frac{n-\gamma}{n-1}\,C_v \ln\left(\frac{T_2}{T_1}\right)$$



PV^n = constant

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1. When $n=0$, PV^0 = constant

   P = constant ⟹ Isobaric.

2. When $n=1$, PV^1 = a constant

   PV = a constant ⟹ Isothermal.

3. When $n=\gamma$, PV^γ = constant ⟹ adiabatic

4. $PV^n = C$

   Taking nth root on both sides, $P^{1/n} V^{\frac{n}{n}} = C^{1/n}$.

   $P^{1/n} V = C_1$

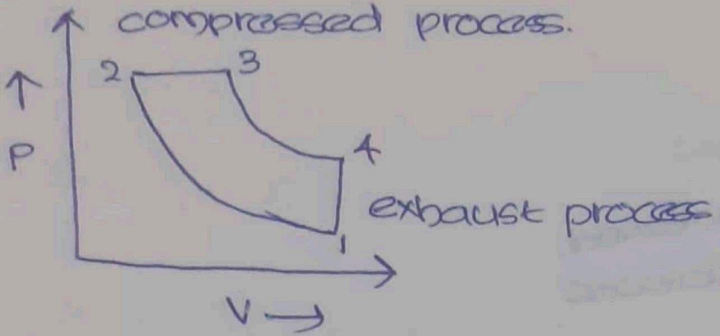
   When $n = \infty$,

   $P^{1/\infty} V = C_1$

   $P^0 V = C$

   V = constant ⟹ Isochoric.

AIR STANDARD CYCLES



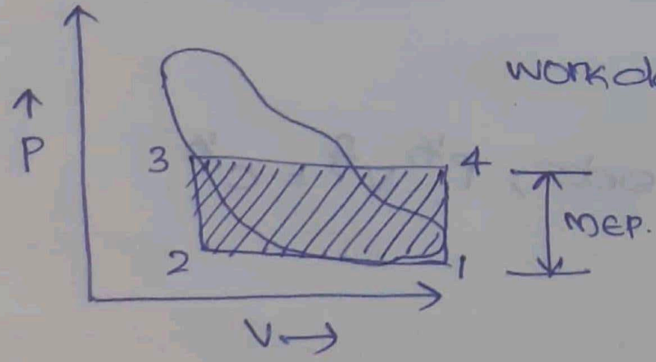
Air standard efficiancy

$$\eta = \frac{\text{work done}}{\text{Heat supplied}}$$

$$= \frac{\text{Heat supplied} - \text{Heat rejected}}{\text{Heat supplied}}$$

$$\boxed{\eta = 1 - \frac{\text{heat rejected}}{\text{heat supplied}}}$$

MEAN EFFECTIVE PRESSURE (MEP)



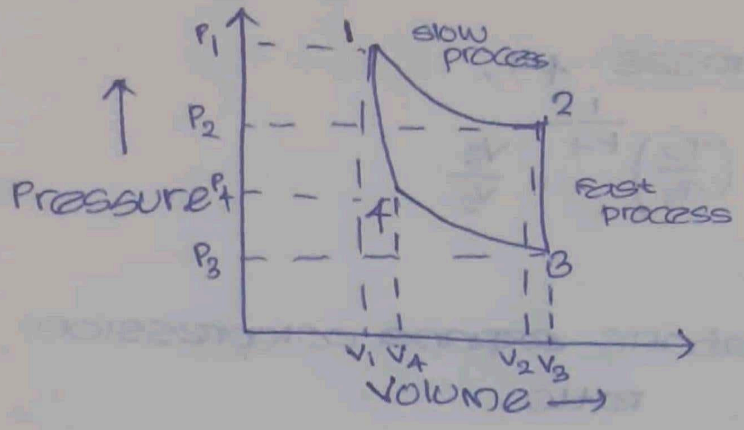
workdone per cycle = Area of the indicator diagram

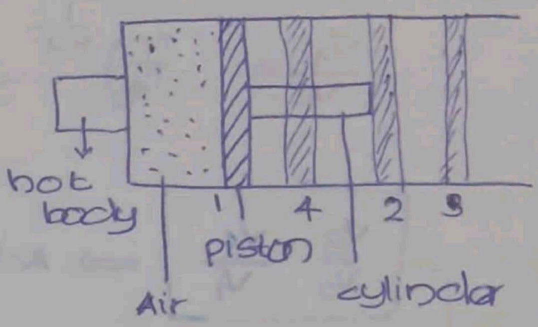
= Swept volume × mep

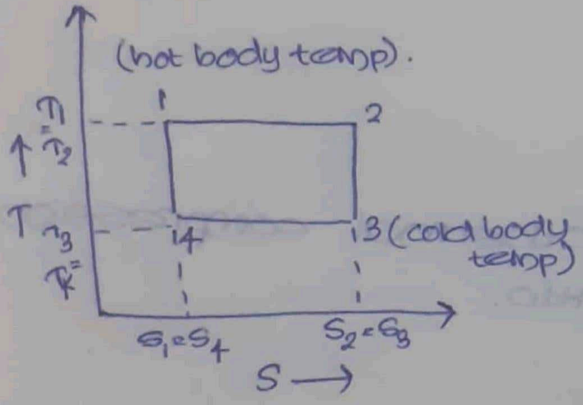
$$\boxed{MEP = \frac{\text{Work done per cycle}}{\text{swept volume}}}$$

$V_1 - V_2$ = Swept volume.

AIR STANDARD CARNOT CYCLE







FOUR REVERSIBLE PROCESS

1-2 : Isothermal expansion.

2-3 : Adiabatic expansion.

3-4 : Isothermal compression.

4-1 : Adiabatic compression.

AIR STANDARD EFFICIENCY

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$$\eta = 1 - \frac{\text{Heat rejected}}{\text{Heat supplied}}$$

Heat rejected during Isothermal process 3-4,

$$Q_{3-4} = P_3V_3 \ln\left(\frac{V_3}{V_4}\right)$$

$$= mRT_3 \ln\left(\frac{V_3}{V_4}\right)$$

Heat supplied during Isothermal process 1-2,

$$Q_{1-2} = P_1V_1 \ln\left(\frac{V_2}{V_1}\right)$$

$$= mRT_1 \ln\left(\frac{V_2}{V_1}\right).$$

From the Adiabatic process, 2-3

$$\frac{V_3}{V_2} = \left(\frac{T_2}{T_3}\right)^{\frac{1}{\gamma-1}}$$

From the adiabatic process 4-1,

$$\frac{V_4}{V_1} = \left(\frac{T_1}{T_4}\right)^{\frac{1}{\gamma-1}} = \left(\frac{T_2}{T_3}\right)^{\frac{1}{\gamma-1}} = \frac{V_3}{V_2}$$

$$\boxed{\frac{V_3}{V_2} = \frac{V_4}{V_1}} \Rightarrow \text{Adiabatic } \text{compression ratio}$$

Adiabatic ~~expansi~~ compression ratio

Adiabatic expansion ratio.

$$\longrightarrow, \quad \frac{V_2}{V_1} = \frac{V_3}{V_4}$$

Isothermal expansion ratio = Isothermal compression ratio.

$$\eta = 1 - \frac{mRT_3 \ln(V_3/V_4)}{mRT_1 \ln(V_2/V_1)}$$

$$\boxed{\eta = 1 - \frac{T_2}{T_1}}$$

7) A carnot cycle works with Adiabatic compressn ratio 5 and Isothermal expansion ratio 2. The volume of air at the beging of isothermal expansion is 0.3 m^3. The maximum temperature and pressure is limited 550 k and 21 bar determine. (take $\gamma = 1.4$)

(i) minimum temperature in cycle.

(ii) thermal effieiancy of cycle.

(iii) pressure at all points.

(iv) work done per cycle.

Ans) $\frac{V_4}{V_1} = 5$

$\frac{V_2}{V_1} = 2.$

$V_1 = 0.3\ m^3$

$P_1 = 21$ bar

$T_1 = T_2 = 550K$

$\gamma = 1.4.$

$V_4 = 5V_1$

$= 5\times0.3$

$= 1.5\ m^3$

$V_2 = 2V_1$

$= 2\times0.3$

$= 0.6\ m^3$

$P_1V_1 = P_2V_2$

$P_2 = \frac{P_1V_1}{V_2}$

$= \frac{21\times0.3\times10^5}{0.62}$

$= \frac{21}{2}$

$= 10.5\times10^5$

$= 10.5$ bar

(ii) $\eta = 1 - \frac{T_2}{T_1}$

$= 1 - \frac{288.9}{550}$

$= \frac{550 - 288.9}{550}$

$= 0.4747$

$= 47.47\%$

$\frac{V_4}{V_1} = \left(\frac{T_1}{T_4}\right)^{\frac{1}{\gamma-1}}$

$5 = \left(\frac{550}{T_4}\right)^{\frac{1}{1.4-1}}$

$= \left(\frac{550}{T_4}\right)^{\frac{1}{0.4}}$

$= \left(\frac{550}{T_4}\right)^{2.5}$

$= \frac{550^{2.5}}{T_4^{2.5}}$

$T_4^{2.5} = \frac{7094253.8}{5}$

$= 1418850.76$

$T_4 = (1418850.76)^{1/2.5}$

3.5 $= 288.9\ k$

$T_4 = T_3$

(iii) $\frac{P_3}{P_2} = \left(\frac{T_3}{T_2}\right)^{\frac{\gamma}{\gamma-1}}$

$P_3 = P_2\left(\frac{T_3}{T_2}\right)^{\frac{\gamma}{\gamma-1}}$

$= 10.5\times10^5\left(\frac{288.92}{550}\right)^{\frac{1.4}{0.4}}$

$= 10.5\times10^5\ (0.52530909)$

$= 110316.7617$

$= 1.10\times10^5$

$\frac{P_4}{P_1} = \left(\frac{T_4}{T_2}\right)^{\frac{\gamma}{\gamma-1}}$

$P_4 = 21\times10^5\left(\frac{288.9}{550}\right)^{\frac{1.4}{0.4}}$

$= 2.20\times10^5$

(iv) work done = heat supplied
− heat rejected

heat supplied $Q_{1-2} = P_1V_1 \ln\left(\frac{V_2}{V_1}\right)$

heat rejected $Q_{3-4} = P_3V_3 \ln\left(\frac{V_3}{V_4}\right)$

$P_1V_1 \ln\left(\frac{V_2}{V_1}\right) = 21\times10^5 \ln\left(\frac{0.6}{0.3}\right) = 6.32\times10^5\times0.3 =$ 437 kJ

$P_3V_3 \ln\left(\frac{V_3}{V_4}\right) = 1.10\times10^5\times3\ \ln\left(\frac{3}{1.5}\right)$

$= 1.10\times10^5\times3\times\ln 2.$

$=$ 228.74

$P_3V_3 = P_4V_4$

$V_3 = \frac{P_4V_4}{P_3}$

$= \frac{2.20\times10^5\times1.5}{1.10\times10^5}$

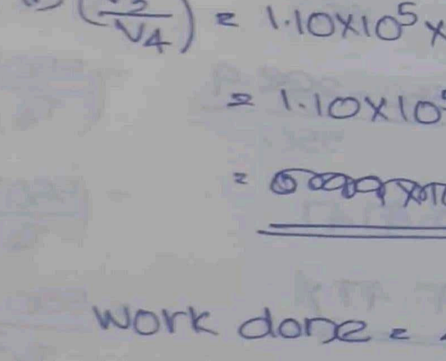
$= 2\times1.5$

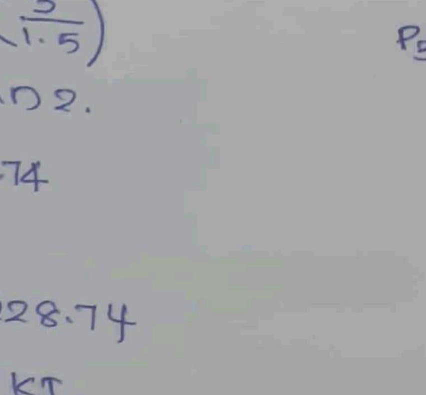
$= \underline{3}$

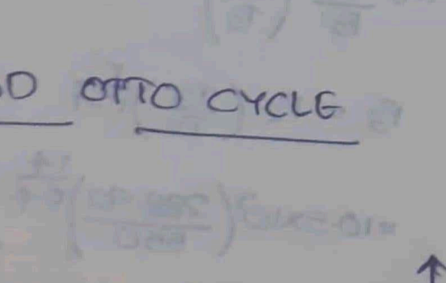
work done = 437 − 228.74

= 208.26 kJ

AIR STANDARD OTTO CYCLE







→ Four reversible process :-

1-2 :- Adiabatic compression.

2-3 :- constant volume heat addition.

3-4 :- Adiabatic expansion.

4-1 :- constant volume heat rejection.

AIR STANDARD EFFICIENCY

Heat supplied during constant volume process 2-3,

$$Q_{2-3} = mC_v(T_3 - T_2)$$

Heat rejected during constant volume process 4-1

$$Q_{4-1} = mC_v(T_4 - T_1)$$

From the Adiabatic Process 1-2,

$$\frac{T_2}{T_1} = \left(\frac{V_1}{V_2}\right)^{\gamma-1} , \quad \frac{V_1}{V_2} = r = \text{compression ratio.}$$

$$T_2 = T_1 r^{\gamma-1} \text{ ——— (1)}$$

From the adiabatic process 3-4,

$$\frac{T_3}{T_4} = \left(\frac{V_4}{V_3}\right)^{\gamma-1}$$

$$= \left(\frac{V_1}{V_2}\right)^{\gamma-1}$$

$$= r^{\gamma-1}$$

$$T_3 = T_4 r^{\gamma-1}$$

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Air standard efficiency, $\eta = 1 - \frac{\text{heat rejected}}{\text{heat supplied}}$

$$= 1 - \frac{mC_v(T_4 - T_1)}{mC_v(T_3 - T_2)}$$

$$= 1 - \frac{T_4 - T_1}{T_3 - T_2}$$

$$= 1 - \frac{T_4 - T_1}{T_4 r^{\gamma-1} - T_1 r^{\gamma-1}}$$

$$= 1 - \frac{1}{r^{\gamma-1}}\left(\frac{\cancel{T_4 - T_1}}{\cancel{T_4 - T_1}}\right)$$

$$\eta = 1 - \frac{1}{r^{\gamma-1}}$$

Q) In an otto cycle condition of air is 27°C and 1 bar at the start of compression. If the clearence volume is 20% of swept volume, Estimate

(i) Temperature at the end of compression.

(ii) Air standard efficiency

Ans) swept volume $= V_1 - V_2$

$V_2 = 0.2(V_1 - V_2)$

$= 0.2V_1 - 0.2V_2$

$1.2V_2 = 0.2V_1$

$\frac{V_1}{V_2} = r = \frac{1.2}{0.2} = 6$

$T_1 = 27^\circ C = 300 K.$ γ in air = 1.4

$$\frac{T_2}{T_1} = r^{\gamma-1}$$

$$T_2 = 300 \times 6^{1.4-1}$$
$$= 300 \times 6^{0.4}$$
$$= 300 \times 2.047672511$$
$$= \underline{\underline{614.3 K}} = \underline{\underline{341.3^\circ C}}$$

KSU
GECI

$$\eta = 1 - \frac{1}{r^{\gamma-1}}$$
$$= 1 - \frac{1}{6^{1.4-1}}$$
$$= 1 - \frac{1}{6^{0.4}}$$
$$= 1 - \frac{1}{2.047672511} = 1 - 0.488$$
$$= 0.512$$
$$= \underline{\underline{51.2\%}}$$

7) In an air standard otto cycle compression ratio is 7 and compression begins at 35°C, $\overset{0.1}{\text{[illegible]}}$ mpa. The Maximum temperature of cycle is 1100°c.

(Cp = 1.005 KJ/kgK
Cv = 0.718 KJ/kgK)

(i) heat supplied per kg of air
(ii) work done
(iii) Air standard efficiency
(iv) Mean effective pressure

Ans) $r = \frac{V_1}{V_2} = \frac{V_4}{V_3} = 7$

$T_1 = 35^\circ C = \underline{\underline{308\,K}}$

$P_1 = 0.1\ Mpa$

$T_3 = 1100^\circ C = \underline{\underline{1373\,K}}$

(i) Heat transfer $= mCv(T_3 - T_2)$.

$$\frac{T_2}{T_1} = r^{r-1}$$

$$T_2 = T_1 r^{r-1}$$

$$= 308 \times 7^{1.4-1}$$

$$= 308 \times 7^{0.4}$$

$$= 308 \times 2.177$$

$$= \underline{\underline{670.8\,K}}$$

~~Heat~~ $mCv(T_3 - T_2) = 1 \times 0.718 \times (1373 - 670.8)$

$$= \underline{\underline{504.1796}}$$

(ii) ~~workdone~~ heat rejected $= mCv(T_4 - T_1)$.

$$\frac{T_3}{T_4} = r^{r-1}$$

$$T_4 = \frac{T_3}{r^{r-1}}$$

$$= \frac{1373}{7^{0.4}}$$

$$= \frac{1373}{2.177}$$

$$= \underline{\underline{630.42\,K}}$$

$mCv(T_4 - T_1) = 1 \times 0.718 \times (630 - 308)$

$$= \underline{\underline{231.196}}$$

(ii) work done $= Q_{3-2} - Q_{4-1}$

$= 504.1796 - 231.196$

$= \underline{\underline{272.9836 \text{ kJ/kg}}}$

(iii) $\eta = 1 - \dfrac{Q_{4-1}}{Q_{2-3}}$

$= 1 - \dfrac{231.196}{504.1796}$

$= \dfrac{504.1796 - 231.196}{504.1796}$

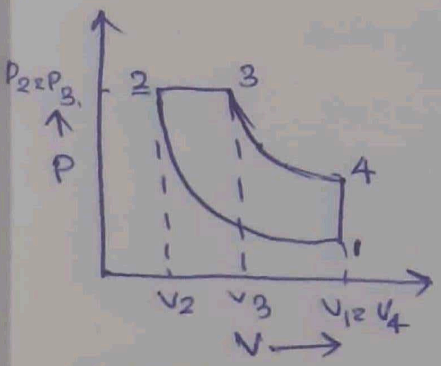
$= \dfrac{272.9836}{504.1796}$

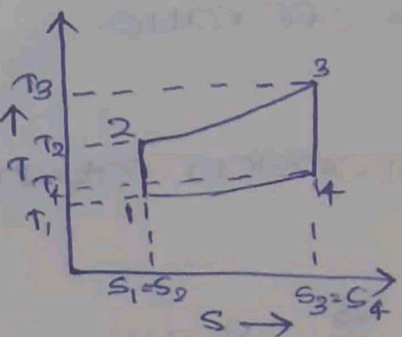
$= 0.54144$

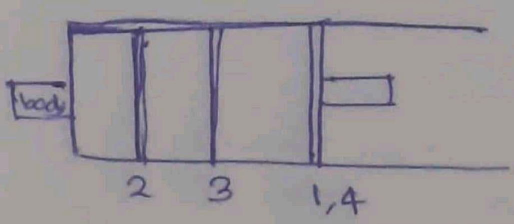
$= \underline{\underline{54.14\%}}$

KSU
GECI

AIR STANDARD DIESEL CYCLE







FOUR REVERSIBLE PROCESS

1-2 :- Adiabatic compression.

2-3 :- constant pressure heat addition.

3-4 :- Adiabatic expansion

4-1 :- constant volume heat rejection.

Air standard efficiency:-

Heat supplied during constant pressure process 2-3, Q_{2-3}

$$Q_{2-3} = mC_p(T_3-T_2)$$

Heat rejected during constant volume process 4-1, Q_{4-1}

$$Q_{4-1} = mC_v(T_4-T_1).$$

$\frac{V_1}{V_2} = r$ = compression ratio.

$\frac{V_3}{V_2} = \rho$ = cut off ratio.

$\frac{V_4}{V_3} = r_1$ = Expansion ratio

$$\frac{V_4}{V_3} = \frac{V_4}{V_2} = \frac{V_2}{V_3}, \quad V_1 = V_4$$

$$= \frac{V_1}{V_2} \cdot \frac{V_2}{V_3}$$

$$= r \, {}^1\!/_\rho . \implies r_1 = r/\rho$$

From the adiabatic process 1-2,

$$\frac{T_2}{T_1} = \left(\frac{V_1}{V_2}\right)^{r-1} = r^{r-1}$$

$$T_2 = T_1 r^{r-1} \text{ ——— } (1)$$

From the constant pressure process 2-3,

$$\frac{V_2}{T_2} = \frac{V_3}{T_3} \qquad \frac{T_3}{T_2} = \frac{V_3}{V_2} = \rho.$$

$$T_3 = T_2 . \rho = T_1 r^{r-1} \rho . \text{ ——— } (2)$$

From the adiabatic process 3-4,

$$\frac{T_3}{T_4} = \left(\frac{V_4}{V_3}\right)^{r-1} = r_1^{r-1}$$

$$= \left(\frac{r}{\rho}\right)^{r-1} = \frac{r^{r-1}}{\rho^{r-1}}$$

KSU /
GECI

$$T_4 = \frac{T_3 \rho^{r-1}}{r^{r-1}}$$

$$\Rightarrow T_4 = T_1 r^{r-1} \rho \frac{\rho^{r-1}}{r^{r-1}}$$

$$T_4 = T_1 \rho^{r} \text{ ——— } (3)$$

$$\eta = 1 - \frac{\text{Heat rejected}}{\text{Heat supplied}}$$

$$= 1 - \frac{mC_v(T_4 - T_1)}{mC_p(T_3 - T_2)}$$

$$\eta = 1 - \frac{T_1 \rho^{\gamma} - T_1}{\gamma (T_1 r^{\gamma-1} \rho - T_1 r^{\gamma-1})}$$

$$= 1 - \frac{T_1 (\rho^{\gamma} - 1)}{\gamma T_1 r^{\gamma-1} (\rho - 1)}$$

$$\boxed{\eta = 1 - \frac{1}{r^{\gamma-1}} \frac{\rho^{\gamma} - 1}{(\rho-1)\gamma}}$$

?) 1 kg of air and 15°C and pressure of 100 kilo pascal is taken through a diesel cycle. The compression ratio is 15 and heat added is 1850 KJ. calculate the Air standard efficiency.

Ans) $m = 1\,kg$

$T_1 = 15^\circ C = 288\,K$

$P_1 = 100\,KPa$

$Q_{added} = 1850\,kJ \qquad r = 15$

$P_1 V_1 = mRT_1$

$$V_1 = \frac{mRT_1}{P_1}$$

$$= \frac{1 \times 287 \times 288}{100 \times 10^3}$$

$$= \underline{\underline{0.82656\,m^3}}$$

$r_1 = \frac{V_1}{V_2} = 15 \Longrightarrow V_2 = \frac{V_1}{15} = 0.055\ m^3$

from 1-2,

$$\frac{T_2}{T_1} = \left(\frac{V_1}{V_2}\right)^{r-1} = r^{r-1}$$

$$T_2 = T_1 r^{r-1}$$

$$= 288 \times 15^{1.4-1}$$

$$= \underline{\underline{850.8\ K}}$$

From process 2-3,

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

$Q = 1850\ kJ$

$Q = mC_p(T_3 - T_2)$

$1850 = 1 \times 1.005\,(T_3 - 850.8)$

$T_3 = \underline{\underline{2691.8\ K}}$

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

$$= \frac{2691.8}{850.8} \times 0.055$$

$$= \underline{\underline{0.174\ m^3}}$$

$\rho = \frac{V_3}{V_2} = \frac{0.174}{0.055} \longrightarrow$ cut off ratio

$= \underline{3.16}$

$$\eta = \frac{1}{15^{1.4-1}} \left(\frac{3.16^{1.4} - 1}{(3.6 - 1)15} \right)$$

$$= \frac{1}{2.954} \left(\frac{5.00 - 1}{2.6 \times 15} \right) = 0.338 \times 0.102564102$$

~~= 0.0347~~

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= [illegible] 0.5515

= 55.15%

7→ In an air standard diesel cycle compression ratio is 16 and at beging of compression temperature is 15°C and pressure is 0.1 mpa. heat is added until the temperature at the end of constant pressure 1450°C. calculate.

(i) cut off ratio
(ii) heat supplied per kg
(iii) cycle efficiency
(iv) Mean effective pressure.

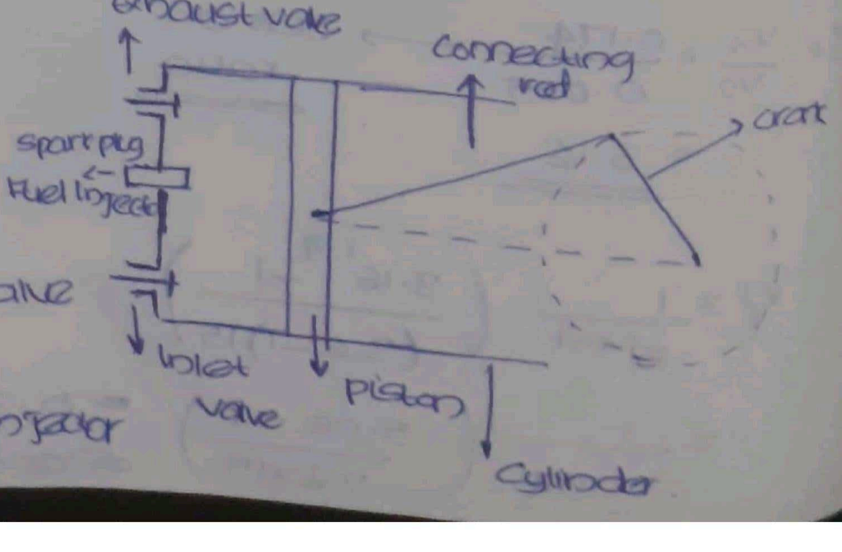
HEAT ENGINES [chemical → Thermal → Mechanical energy]

(Internal combustion) IC engine

EC engine. (external combusti

→ parts of IC engine

* cylinder
* piston
* connecting rod
* crank
* Inlet and exhaust valve
* Flywheel
* spark plug / Fuel Injector



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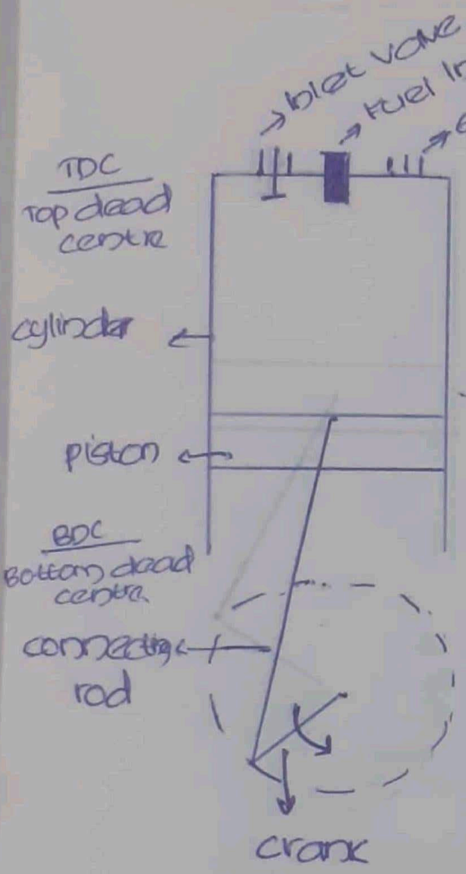
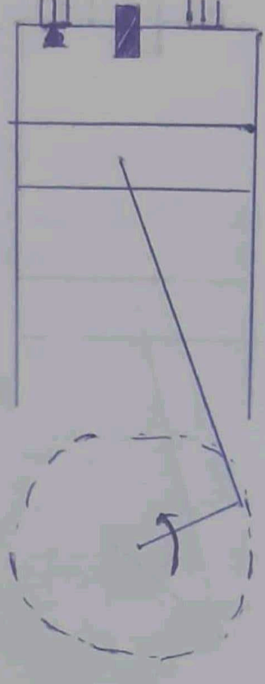
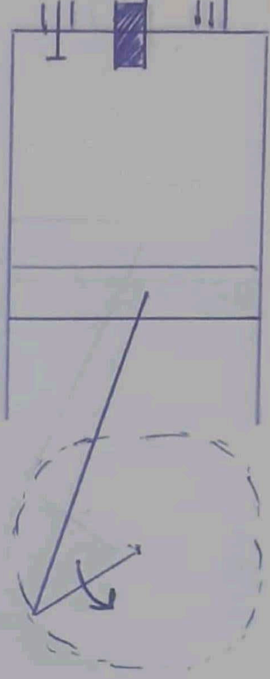
WORKING OF 4-STROKE DIESEL ENGINE (COMPRESSION IGNITION CI)



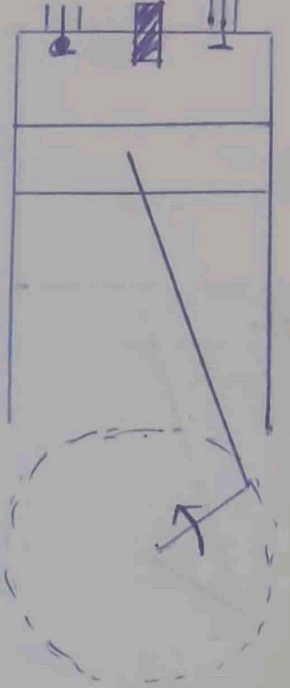
suction



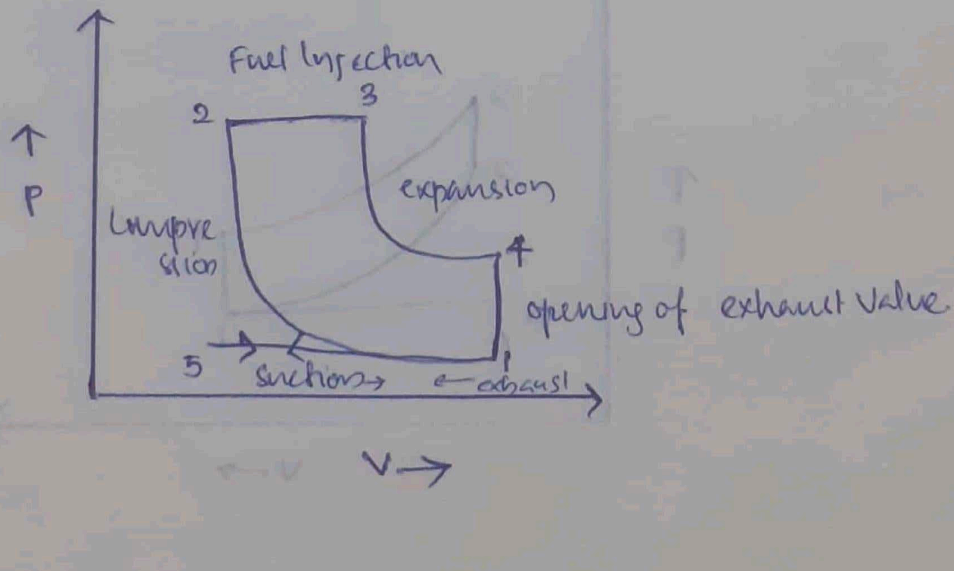
compression



expansion/ working



exhaust



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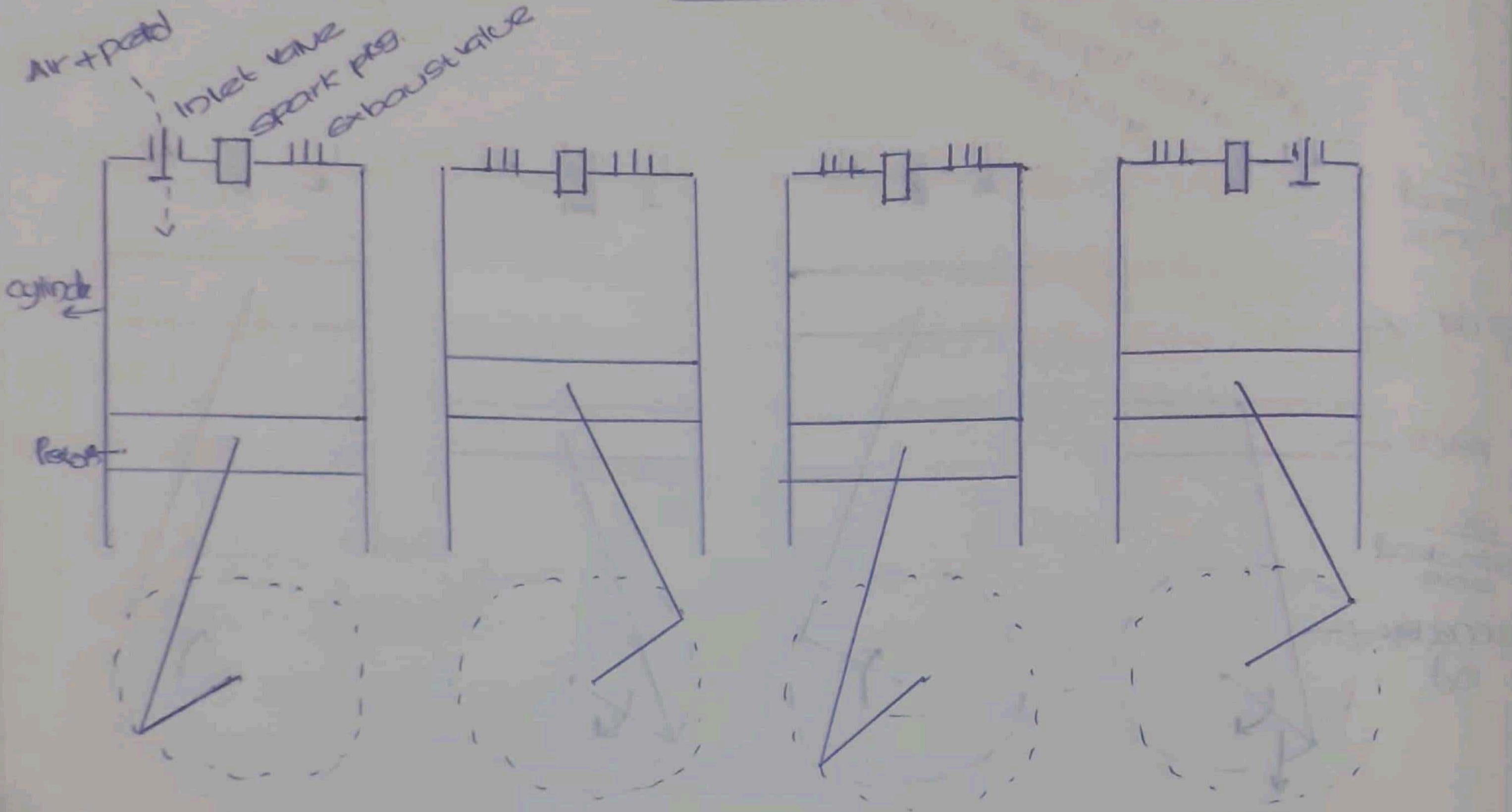
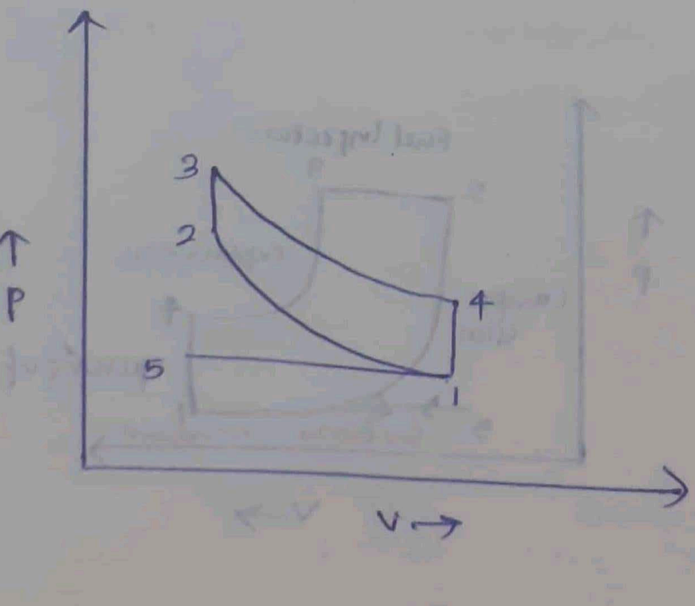
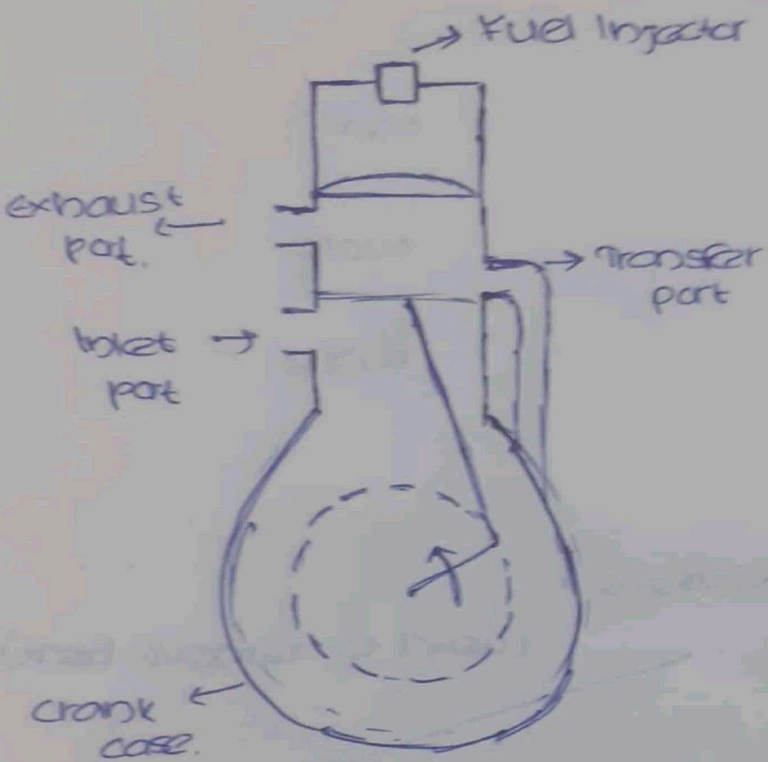
WORKING OF PETROL ENGINE (SPARK IGNITION SI)





WORKING OF 2-STROKE DIESEL ENGINES



2-STROKES

upward (suction and compression)

downward (expansion and exhaust)

COMPARISON OF SI AND CI ENGINE

	SI	CI
(i) working cycle -	otto cycle	diesel cycle.
(ii) Fuel -	petrol	diesel.
(iii) Method of fuel introduction -	During suction stroke, as fuel air mixture.	At the end of compression stroke, in the form of fine spray.
(iv) Method of fuel ignition -	using spark plug	using fuel injector auto ignition.

(v)	fuel economy	- less	more.
(vi)	compression ratio	- less (6-12)	more (15-25)
(vii)	weight	- less	more.
(viii)	Initial cost	- less	more
(ix)	maintenance cost	- less	more.

COOLING SYSTEM IN IC ENGINES

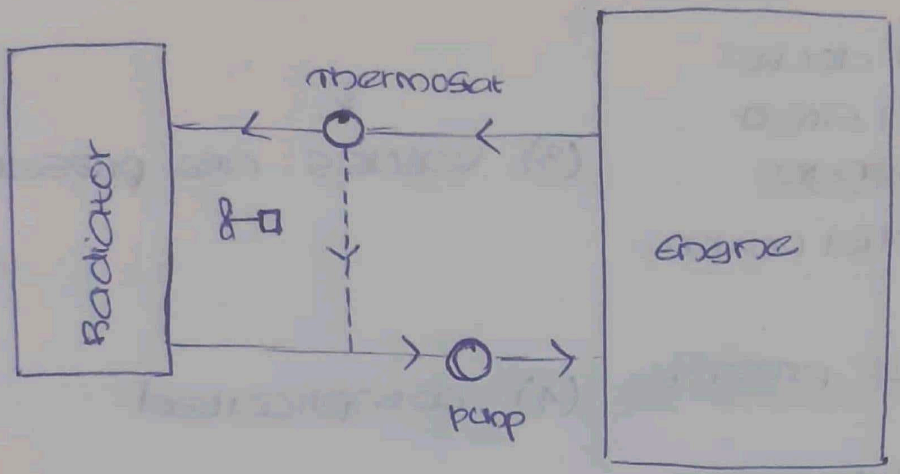
(used to remove heat).

Air cooling

- → used in Aeroplanes.
- → Absence of radiator and connected devices
- → can be operated in all weather condition
- → vibrate and amplifiers.

Liquid cooling.

- → presence of radiation
- → Inorder to avoid freezing we use antifreezing substanes.
- → requires pumping.



LUBRICATION SYSTEM

Types :—

(i) Mist lubrication

(ii) wet sump — splash / pressure feed.

(iii) Dry sump.

COMPARISON OF 2-STROKE AND 4-STROKE ENGINES

2 STROKE	4 STROKE
(1.) one cycle is completed by 2 strokes of the piston or 1 revolution of crank shaft.	(1.) 4 strokes of piston or 2 revolution of crank shaft.

(2) one power stroke per 2-strokes ⟹ theoretically double the power of a similar to 4-stroke engine. Practically 30% extra power.	(2) one power stroke per 4 stroke.
(3). No values are present	(3) values are present
(4). Simple construction.	(4). complicated
(5). Initial cost and maintainance cost less	(5). More.
(6). scavenging is poor	(6) Better
(7). Less time for heat dissipation and less thermal efficiency.	(7) More time, since separate exhaust and suction. More thermal efficie
(8) slow speed	(8) High speed
(9) Turning moment is more uniform compared to 4-stroke.	