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MADE EASY

MECHANICAL ENGINEERING

Machine Design

By-Padmesh Sir

- Theory
- Explanation
- Derivation
- Example
- Shortcuts
- Previous Years Question With Solution

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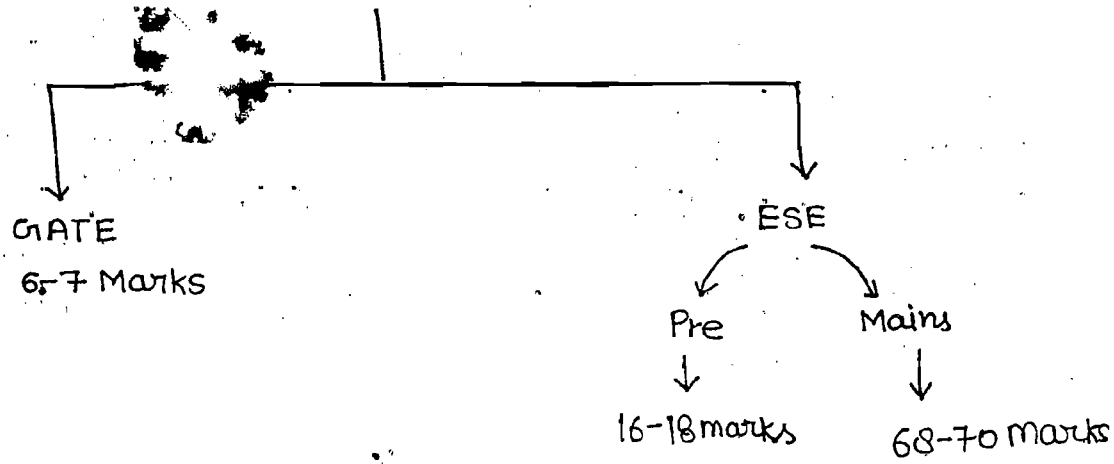
MACHINE DESIGN (MD)

(or)

MACHINE ELEMENT DESIGN (MED)

(or)

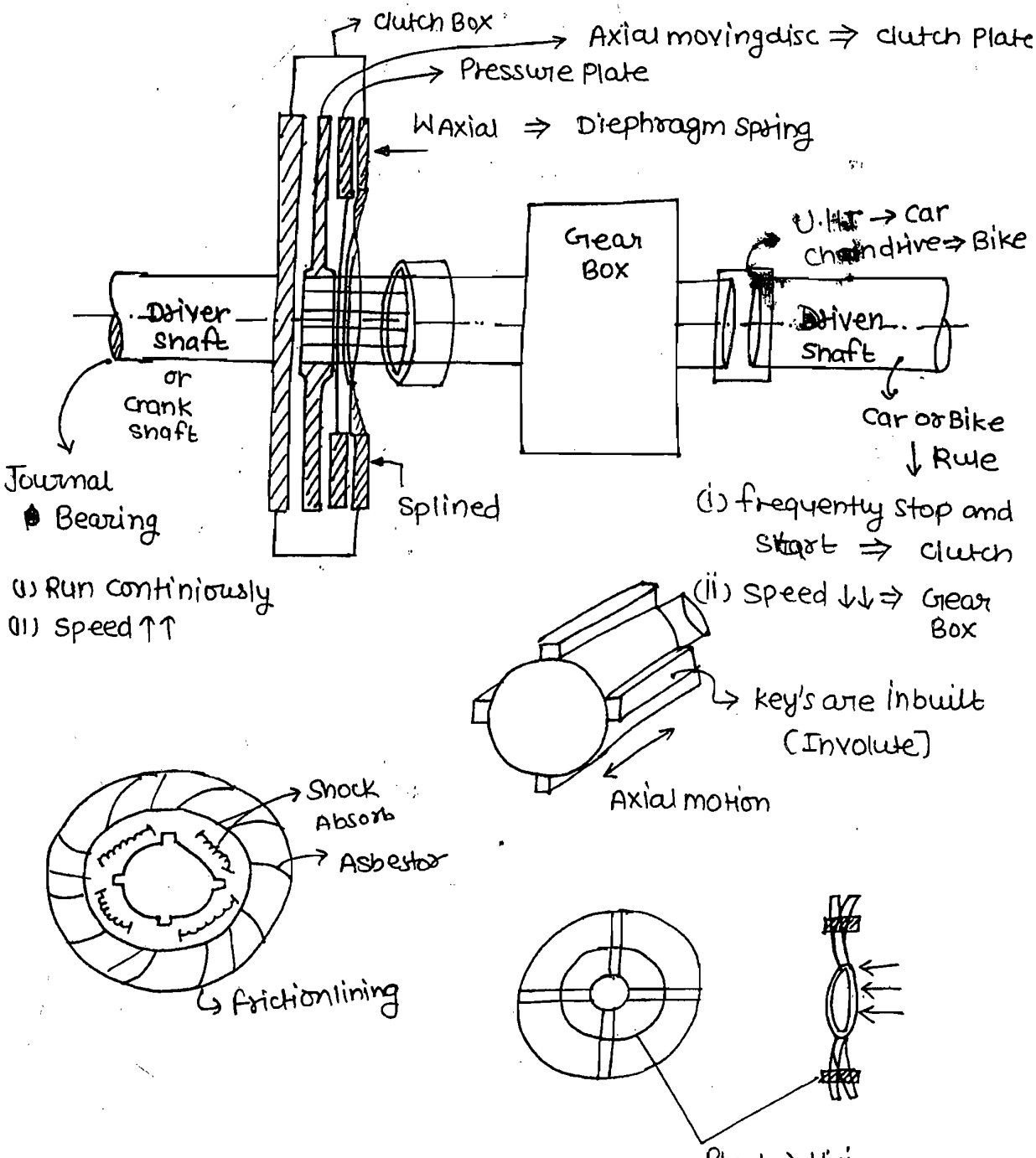
DESIGN OF MACHINE ELEMENT (DME)



(I) Clutches
(II) Brakes
(III) Gear ⇒ (Spur Gear)
(IV) Riveted Joint
(V) Bolted Joint
(VI) Welded Joint
(VII) Bearing
(VIII) Fatigue design of shaft
(IX) Spring
(X) Design of flywheel [only ESE]

clutch :→

It is defined as a machine element which is use to engage and disengage driver and the driven shaft at the wheel without stopping the prime mover.



Q Why clutches are prefer at high speed side

Ans → Power = $T_f \times \omega$ ↑↑↑

High speed

T_f → Required torque Less
⇓
Clutch design Simple

→ To minimize wear and Losses
clutch @ Low speed side
Power = $T_f \cdot \omega$ ↓↓↓
↓
(Torque Required will be more)

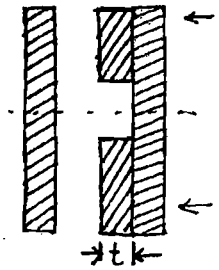
clutch

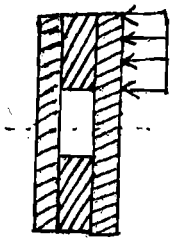
Wear friction is responsible for wear

[UPT]
NEW CLUTCH
(Uniform wear नहीं होता है)

wear friction $\propto V$ → Linear Velocity

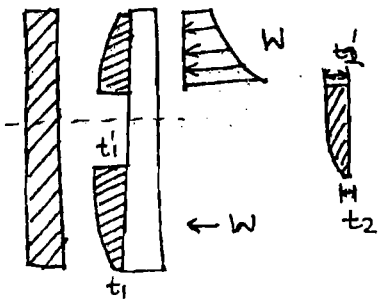
wear friction $\propto P$ → Pressure

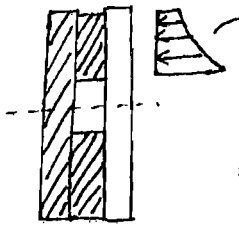




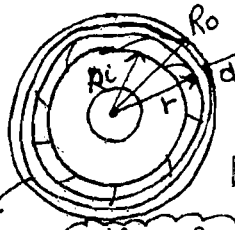
P_{ind} = uniform Pressure
⇓
Perfect Engage

[UWT]
OLD CLUTCH
(Uniform wear होता है)





P_{ind} → Non uniform Pressure
⇓
Perfect Engage नहीं होता है



R_o → outer radius of Lining
R_i → Inner radius of Lining

$P_{ind} = \dfrac{W}{\pi (R_o^2 - R_i^2)}$

$P_{ind} = P$ (uniform Pressure Theory) (UPT)

$\int_{R_i}^{R_o} 2\pi r \cdot dr \cdot P = \int_0^W dw$

$\boxed{P_{ind} = \dfrac{W}{\pi (R_o^2 - R_i^2)}}$

New Clutch

For Safe Cond^n
$P_{ind} \le P_{per}$ (or) P_{allow}

$\dfrac{W}{\pi (R_o^2 - R_i^2)} \le P_{per}$

$W_{max} = \pi (R_o^2 - R_i^2) P_{per}$ → Strength of New Lining in terms of Load

Pressure · r = constant ⇒ P · r = C
wear friction = constant
⇓
Uniform wear Theory (UWT)

$\int 2\pi r P \cdot dr = \int dw$

$2\pi \int_{R_i}^{R_o} \frac{c}{r} \cdot r dr = W \Rightarrow \boxed{c = \dfrac{W}{2\pi (R_o - R_i)}}$

$\boxed{P_{ind} = \dfrac{W}{2\pi r (R_o - R_i)}}$

$t - t_1 > t - t_1'$, $t_1 - t_2 = t_2 - t_2'$

For Safe cond^n
$(P_{ind})_{max} \le P_{per}$

$\uparrow P_{ind} = \dfrac{W}{2\pi r (R_o - R_i)}$

$(P_{ind})_{max} = \dfrac{W}{2\pi R_i (R_o - R_i)}$

$\dfrac{W}{2\pi R_i (R_o - R_i)} \le P_{per}$

$W_{max} = 2\pi R_i (R_o - R_i) P_{per}$ → Strength of old lining

New clutch

Frictional torque

$F_r = \mu R_N = \mu dW = 2\pi r dr \cdot p \cdot \mu$

$$\int dT_f = \int_{R_i}^{R_o} 2\pi\mu p r^2 dr = 2\pi\mu p \int_{R_i}^{R_o} r^2 dr$$

$$\boxed{T_{f_{max}} = \frac{2}{3}\mu\pi P_{per}(R_o^3 - R_i^3)}$$

Old clutch

$$\int dT_f = \int_{R_o} 2\pi\mu \cdot p \cdot r^2 dr$$

$$T_f = 2\pi\mu \int_{R_i} \frac{c}{r} \cdot r^2 dr$$

$$T_f = \pi\mu c (R_o^2 - R_i^2)$$

$$c = \frac{W}{2\pi(R_o - R_i)}$$

$$T_{f_{max}} = \mu W_{max}\left(\frac{R_o + R_i}{2}\right)$$

$$\boxed{T_{f_{max}} = \mu\pi P_{per} R_i (R_o^2 - R_i^2)}$$

NEW CLUTCH $\Rightarrow$ UPT

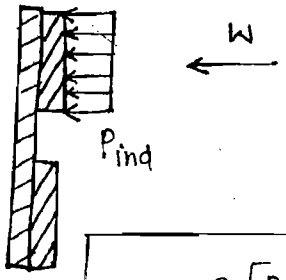
$\Downarrow$

$P_{ind} = c$

- $P_{ind} = \dfrac{W}{\pi(R_o^2 - R_i^2)}$
- Safe condition

$P_{ind} \le P_{per}$

- $W_{max} = \pi(R_o^2 - R_i^2) P_{per}$
- $T_{f_{max}} = \frac{2}{3}\mu\pi P_{per}(R_o^3 - R_i^3)$



$$\boxed{R_{eff} = \frac{2}{3}\left[\frac{R_o^3 - R_i^3}{R_o^2 - R_i^2}\right]}$$

OLD CLUTCH $\Rightarrow$ UWT

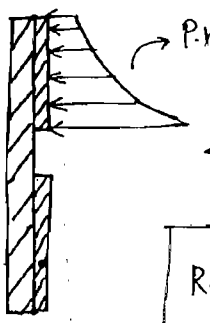
$\Downarrow$

$P \cdot r = c$

- $P_{ind} = \dfrac{W}{2\pi r(R_o - R_i)}$

Safe condition

- $(P_{ind})_{max} \le P_{per}$
- $W_{max} = 2\pi R_i (R_o - R_i) P_{per}$
- $T_{f_{max}} = \mu\pi P_{per}(R_o^2 - R_i^2)$



$$\boxed{R_{eff} = \frac{R_o + R_i}{2}}$$