Design of Machines and Mechanical Systems (PC-BTM711)

Session 17

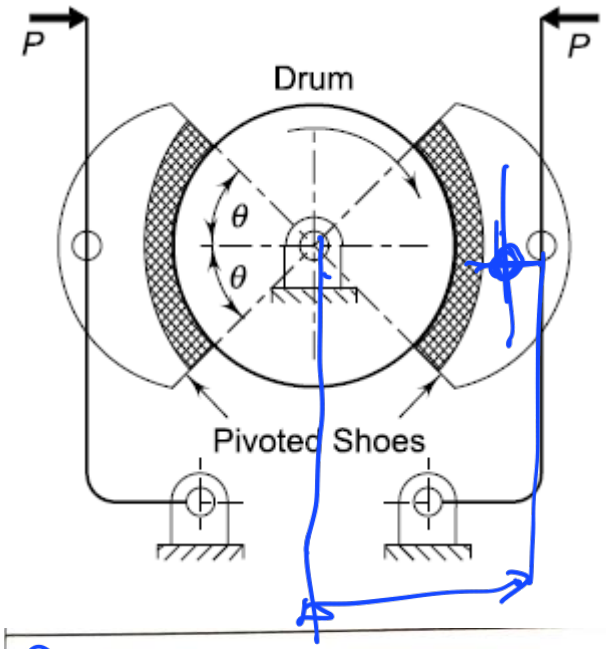
Module 4: Design of Disk Brakes and

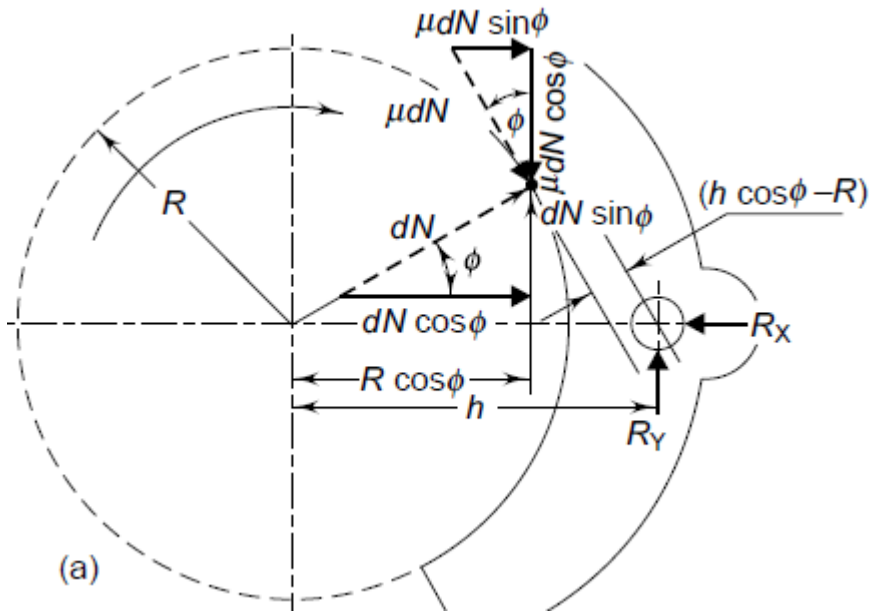
Design of Clutches

Session Outcomes

- Design of disk brake
- Discuss thermal considerations in brakes
- Discuss types of clutches
- Obtain torque carrying capacity of single plate clutch

Pivoted Block Brake with Long Shoe





$h = \dfrac{4R \sin\theta}{2\theta + \sin 2\theta}$	(12.10)	h = distance of pivot from axis of brake drum (mm) R = radius of brake drum (mm) θ = semi-block angle of each shoe (rad)
$M_t = 2\mu R^2 w p_{max} \sin\theta$	(12.11)	M_t = braking torque capacity of each shoe (N-mm) μ = coefficient of friction between friction lining and drum w = width of friction lining (mm) p_{max} = maximum intensity of pressure between friction lining and brake drum (MPa or N/mm^2)
$R_x = \dfrac{1}{2} R w p_{max} (2\theta + \sin 2\theta)$	(12.12)	R_x = reaction at each pivot in X direction (N)
$R_y = \dfrac{1}{2} \mu R w p_{max} (2\theta + \sin 2\theta)$	(12.13)	R_y = reaction at each pivot in Y direction (N)

DDB T12.3

Ref: Bhandari V.B., Design of Machine Elements (2017)

QUIZ

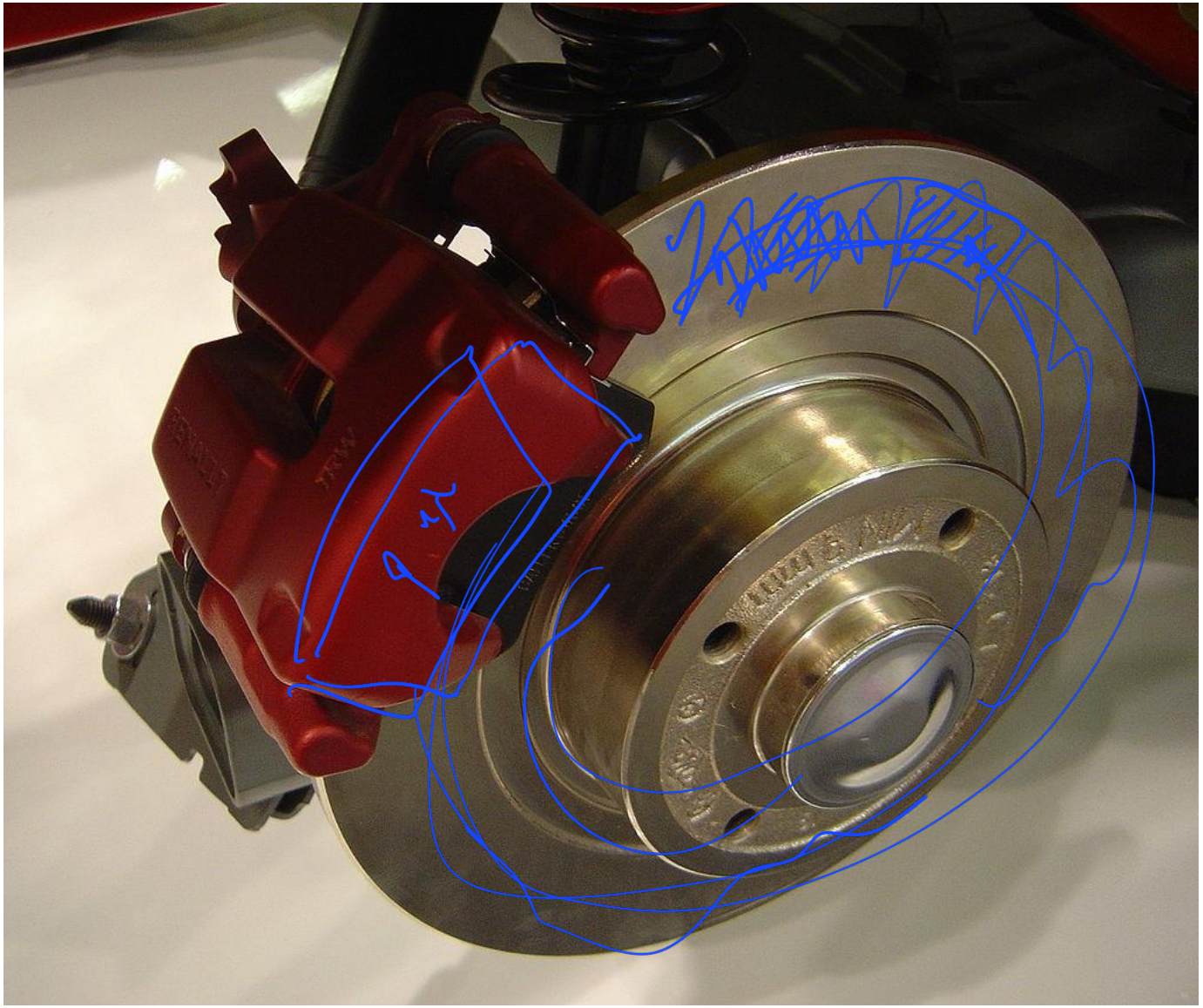
Pivoted Block Brake

Which of the statement is TRUE regarding pivoted block brake with long shoe?

1) Frictional forces tend to unseat the block
2) Used in hoists and cranes
3) Easy to fabricate

Disk Brake

https://www.youtube.com/watch?v=80sjvvdj-sg

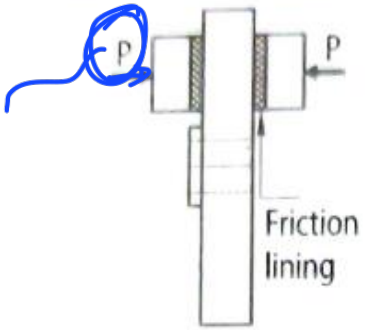


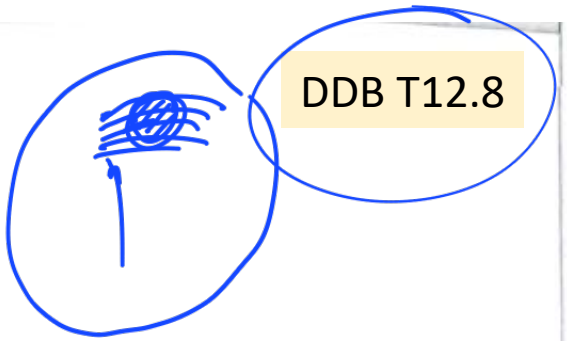
https://en.wikipedia.org/wiki/Disc_brake#/media/File:Disk_brake_dsc03682.jpg

Features of disk brakes

- Simple to _____ and _____
- _____ torque capacity in small volume
- _____ surface area for heat dissipation – no thermal fading of friction lining
- _____ to control
- It can be _____ self-locking
- Effective in _____ direction of rotation
- The entire plate surface is not covered by friction lining as it would result in _____

Design of Disk Brake with Annual Pad

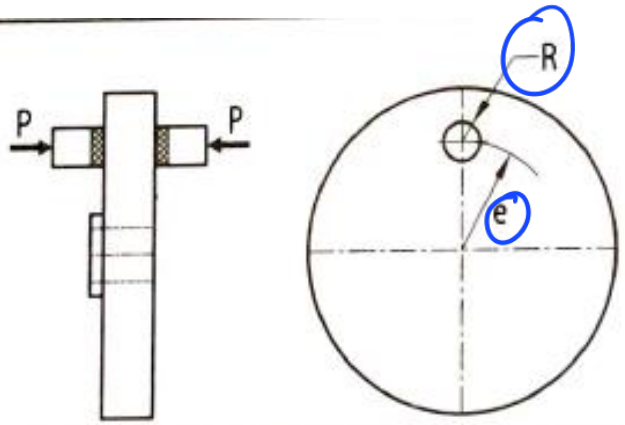




$R_f = \frac{2}{3}\frac{(R_o^3 - R_i^3)}{(R_o^2 - R_i^2)}$	(12.44)	R_o = outer radius of pad (mm) R_i = inner radius of pad (mm) R_f = friction radius (mm) (Uniform Pressure Theory)
$M_t = \mu P R_f$	(12.45)	M_t = torque capacity of pad (N-mm) μ = coefficient of friction P = actuating force (N)
$A = \frac{1}{2}\theta(R_o^2 - R_i^2)$	(12.46)	A = area of pad (mm^2) θ = angle subtended by pad with axis of disk (rad)
$P = p_{ave} A$	(12.47)	p_{ave} = average pressure between friction lining and disk (MPa or N/mm^2)

Ref: Bhandari V.B., Design of Machine Elements (2017)

Design of Disk Brake with Circular Pad



DDB T12.8

$R_f = \delta e$ (12.48)	R_f = friction radius (mm) e = distance of pad centre from axis of disk (mm) R = radius of pad (mm)

Values of δ for circular-pad caliper disk brake

(R/e)	δ
0.0	1.0000
0.1	0.9833
0.2	0.9693
0.3	0.9572
0.4	0.9467
0.5	0.9375

Ref: Bhandari V.B., Design of Machine Elements (2017)

Thermal Considerations

Table 12.9 *Properties of friction materials for brakes*

Material	Coefficient of friction	Permissible temperature (°C)	Intensity of pressure (MPa or N/mm²)
Cast iron on cast iron	0.15–0.20	300	1.00
Wood on cast iron	0.25–0.30	50	0.35
Leather on cast iron	0.30–0.50	50	0.25
Woven-asbestos on metal	0.35–0.40	250	0.65
Moulded-asbestos on metal	0.40–0.45	250	1.00
Sintered metal on metal	0.20–0.40	300	2.75

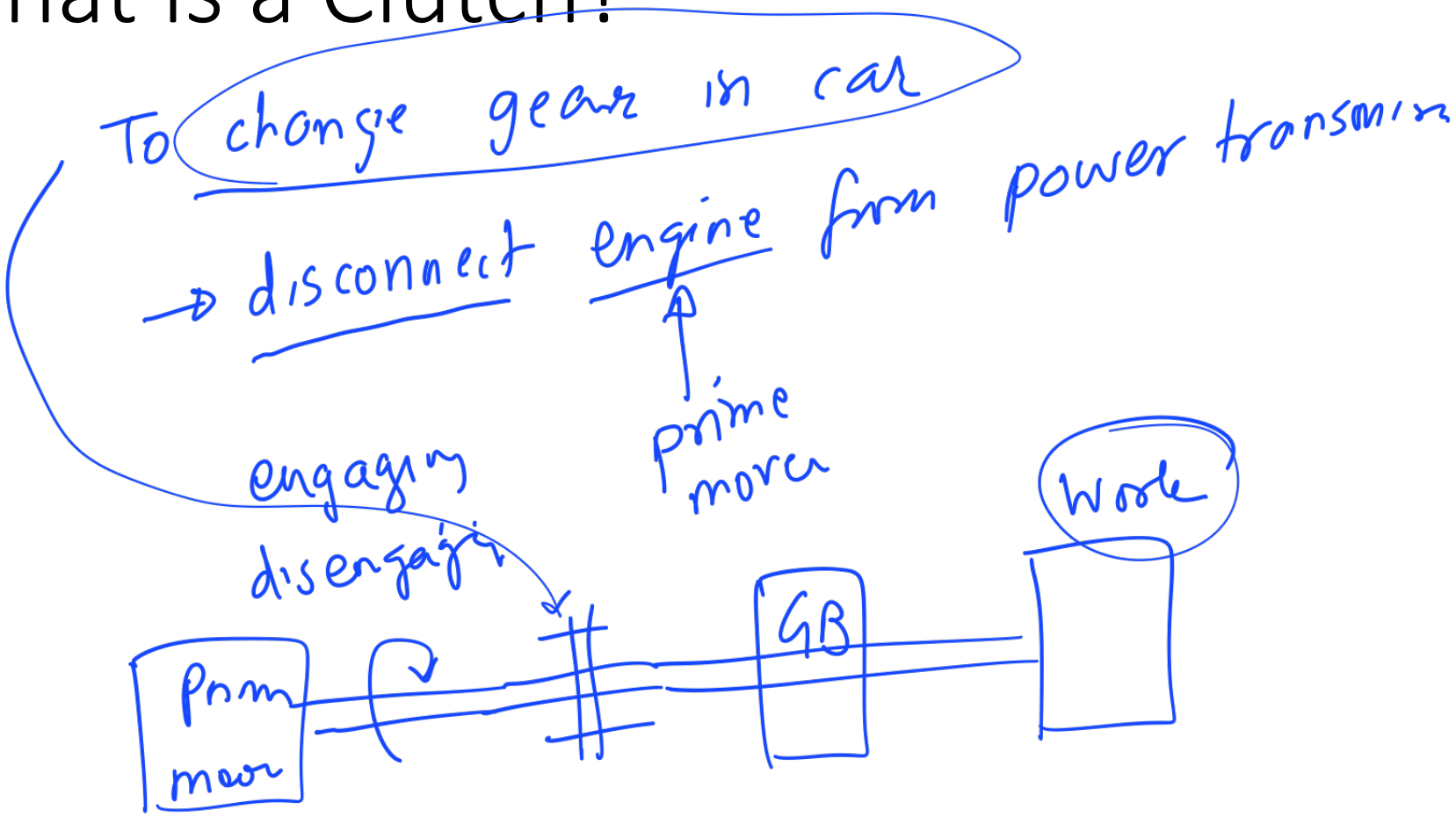
Table 12.10 *Recommended values of product (pv)*

[p = *Intensity of normal pressure* (MPa or N/mm²), v = *Rubbing speed* (m/min)]

Application	Product (pv)
Intermittent applications, comparatively long period of rest and poor dissipation of heat	115
Continuous application and poor dissipation of heat	58
Continuous application and good dissipation of heat	175
Vehicle-brakes	125

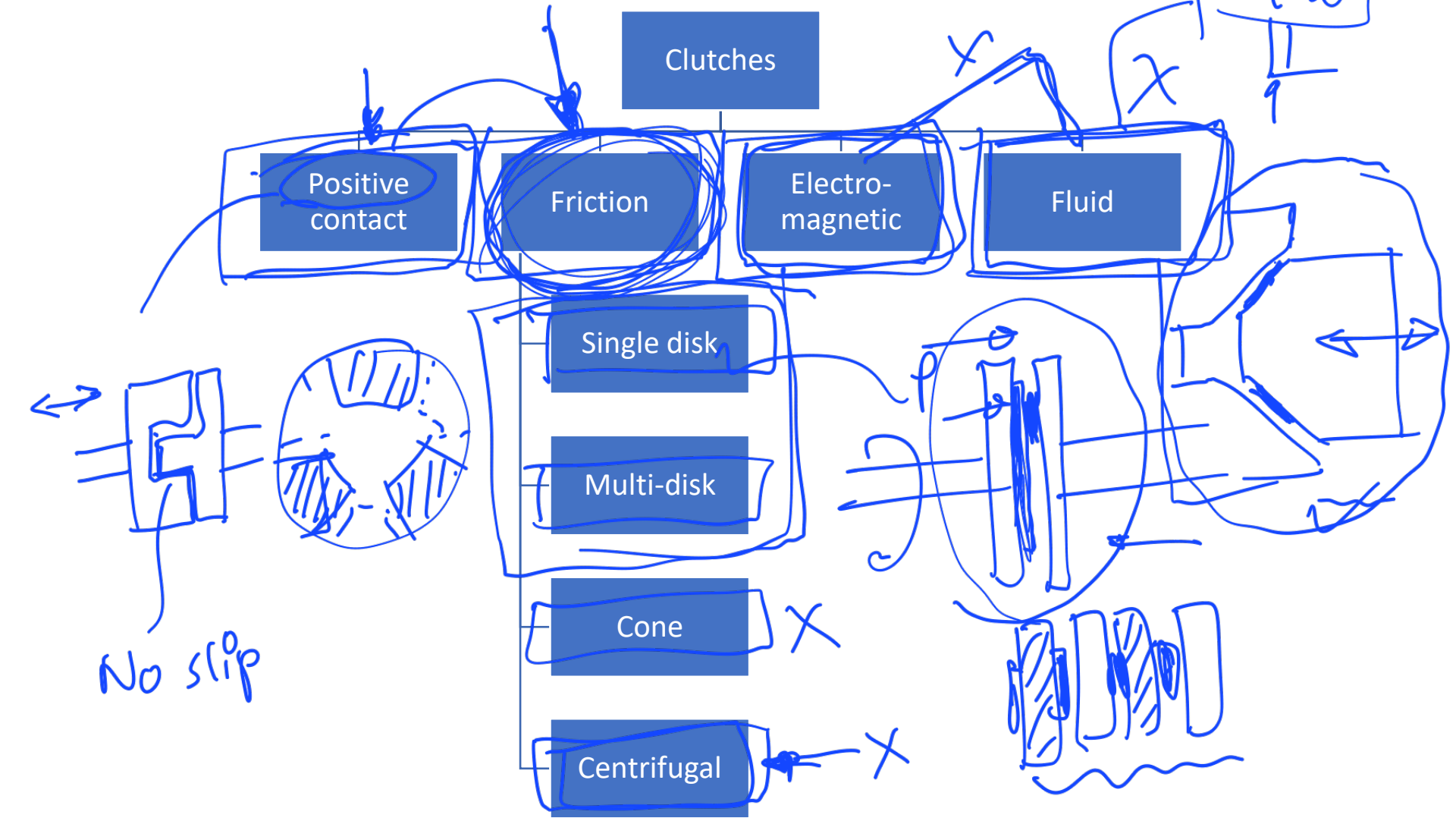
Note: In preliminary design of brakes, product (pv) is considered in place of temperature rise.

What is a Clutch?

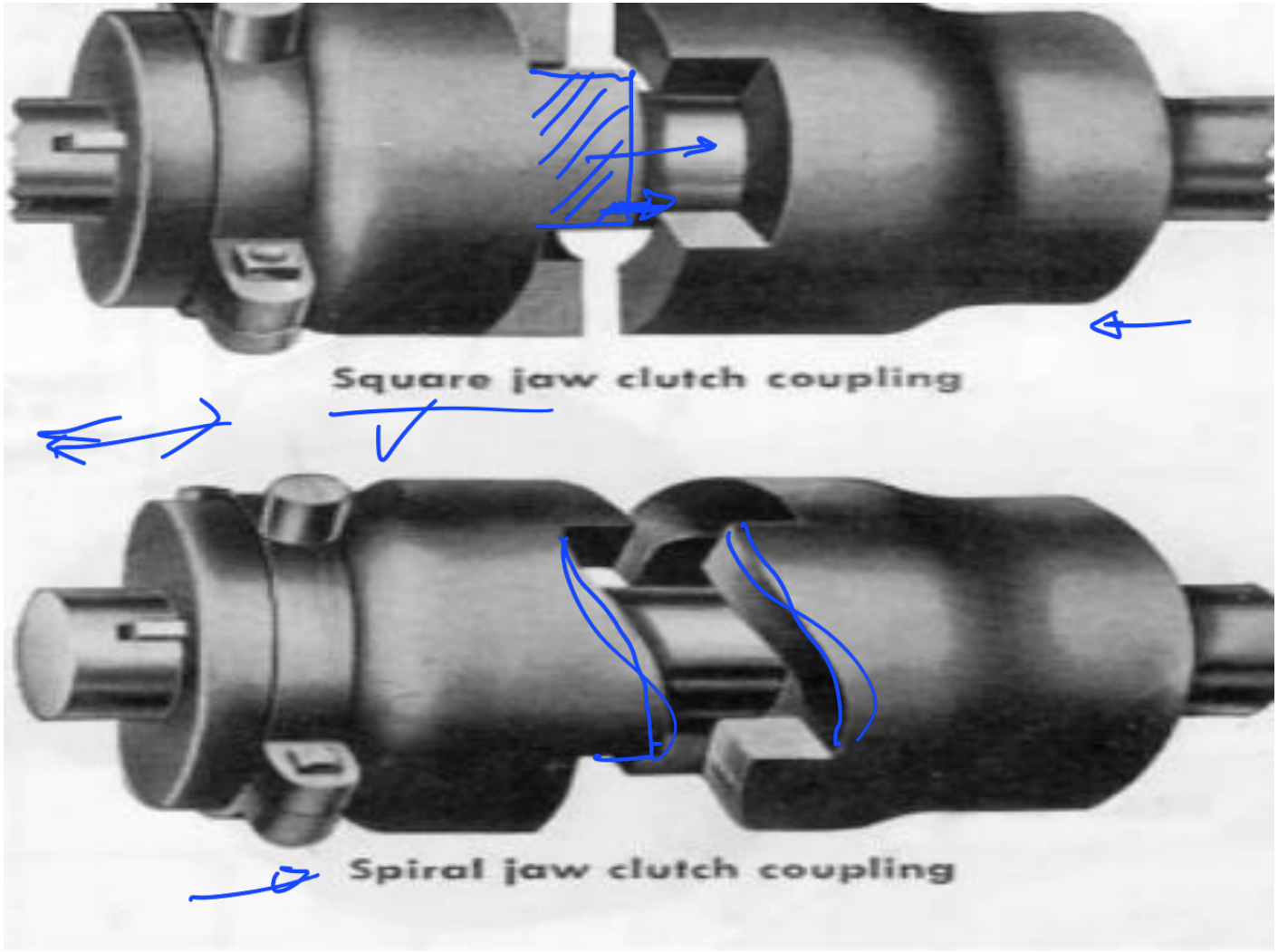


SELF-STUDY

Classification of Clutches



Positive Contact Clutch



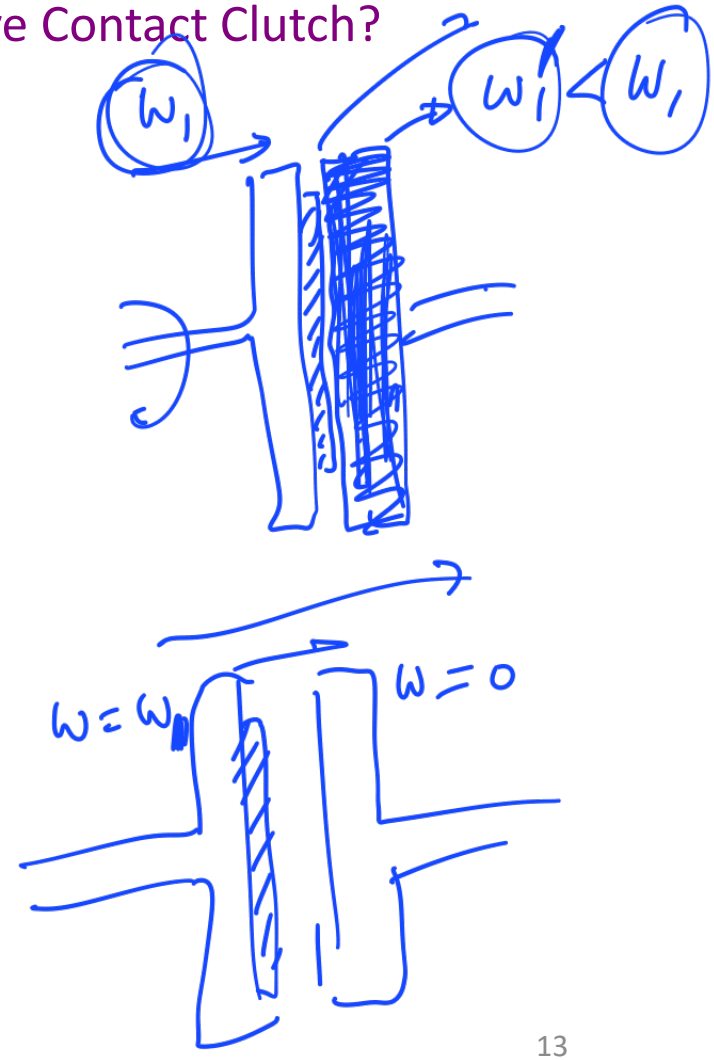
https://www.google.com/url?sa=i&source=images&cd=&ved=2ahUKEwiVgJuW5_jkAhWK7XMBHXc4C_IQjRx6BAgBEAQ&url=https%3A%2F%2Fwww.slideshare.net%2Fdeepk1984%2Fcluitch-ppt&psig=AOvVaw2eEAD9shYrSEUrUHNv16XL&ust=1569941807312190

QUIZ

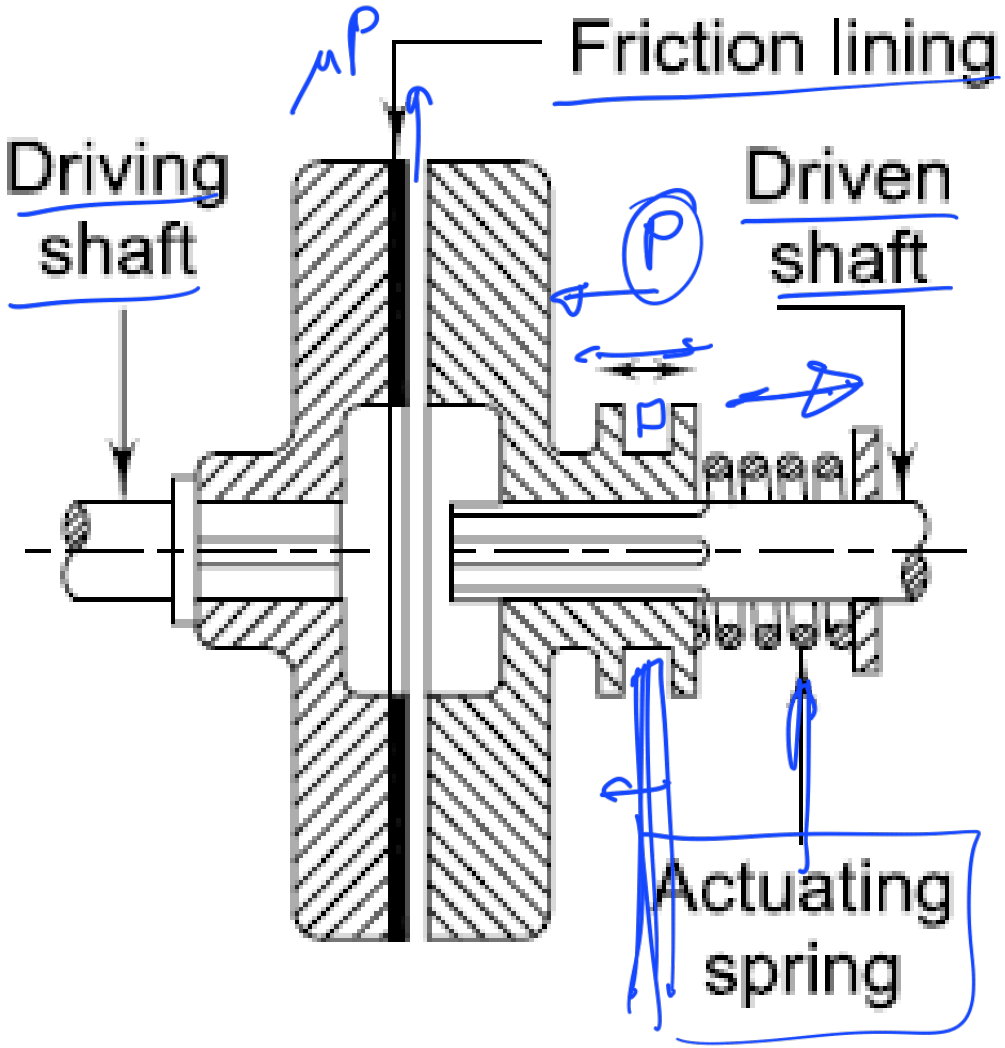
Positive Contact Clutch

Which of the statement is FALSE regarding Positive Contact Clutch?

1) No slip
2) No heat generation
3) Engagement at high speeds – False

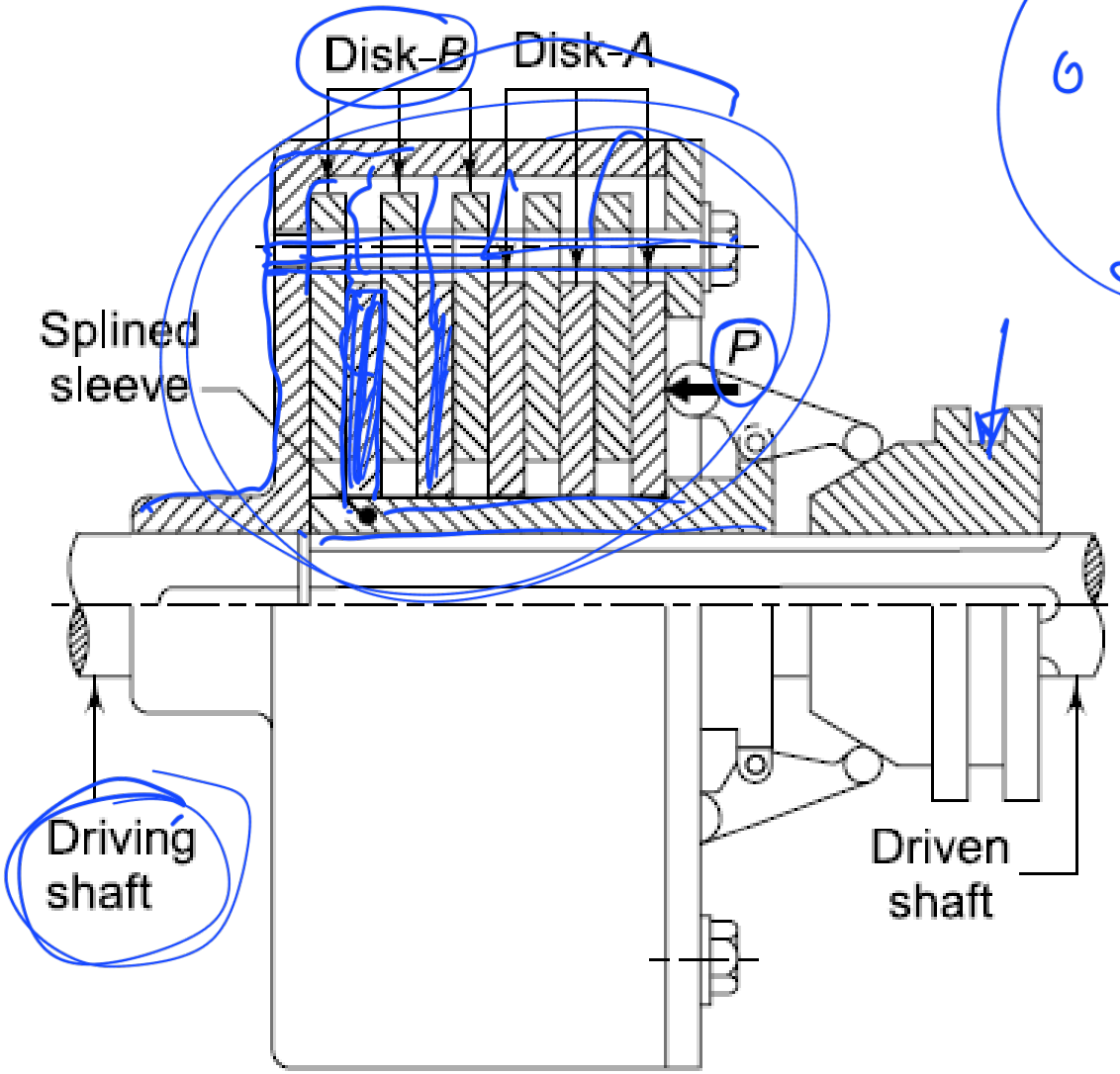


Single Plate Clutch



Ref: Bhandari V.B., Design of Machine Elements (2017)

Multi-plate Clutch



Ref: Bhandari V.B., Design of Machine Elements (2017)

QUIZ

Single Plate Clutch

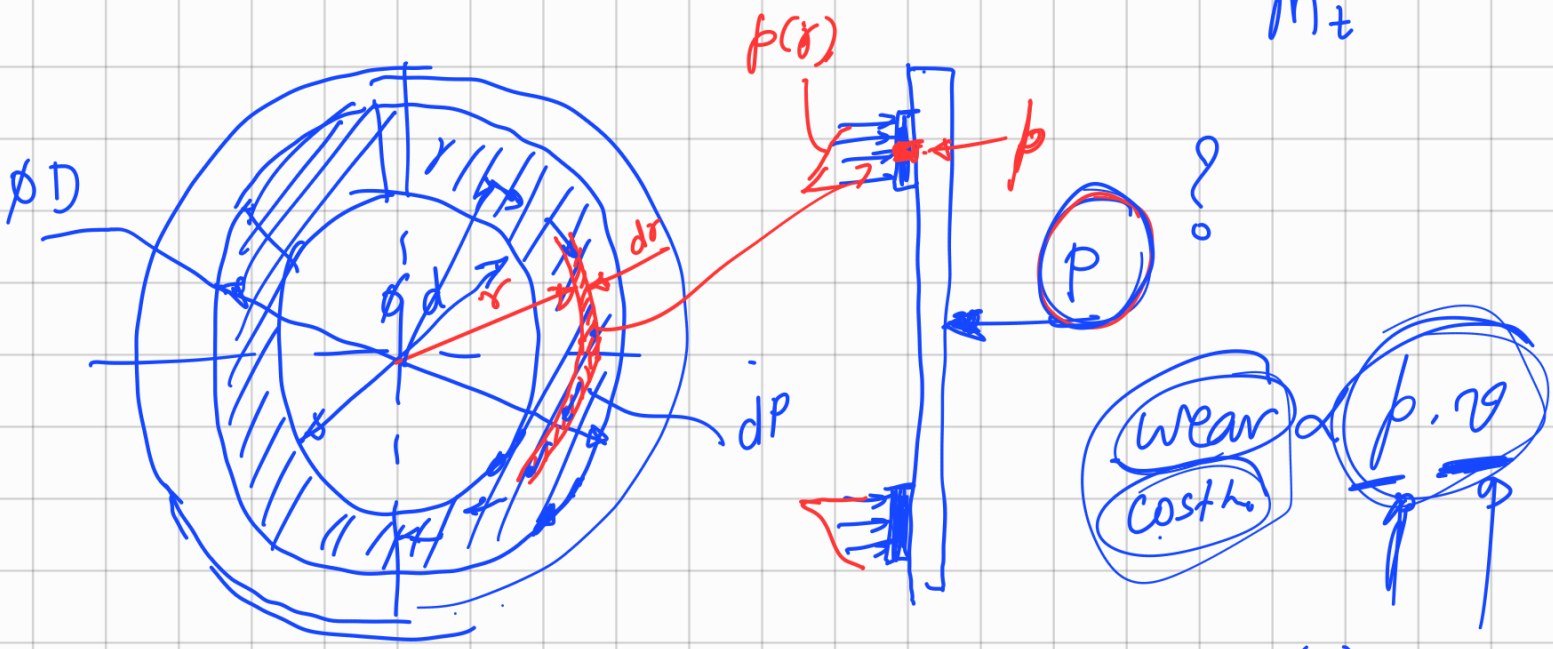
For the **same power transmission capacity**, which of following is **TRUE** about **single plate clutch** as compared to multi-plate clutch?

1) More radial space, More heat generation
2) Less radial space, Less heat generation
3) More radial space, Less heat generation

Torque Capacity of Clutch

Torque Capacity

M_t



$$dP = p \times (2\pi r \cdot dr)$$

$$P = \int_{d/2}^{D/2} dP = 2\pi \int_{d/2}^{D/2} p \cdot r \cdot dr$$

$p(r)$

$$M_t = \int_{d/2}^{D/2} dM_t = \int_{d/2}^{D/2} (\mu \, dP) \cdot r$$

$$= \int_{d/2}^{D/2} \mu \cdot p \cdot (2\pi r) dr \cdot r$$

$$M_t = 2\pi\mu \int_{d/2}^{D/2} p \cdot r^2 \cdot dr$$