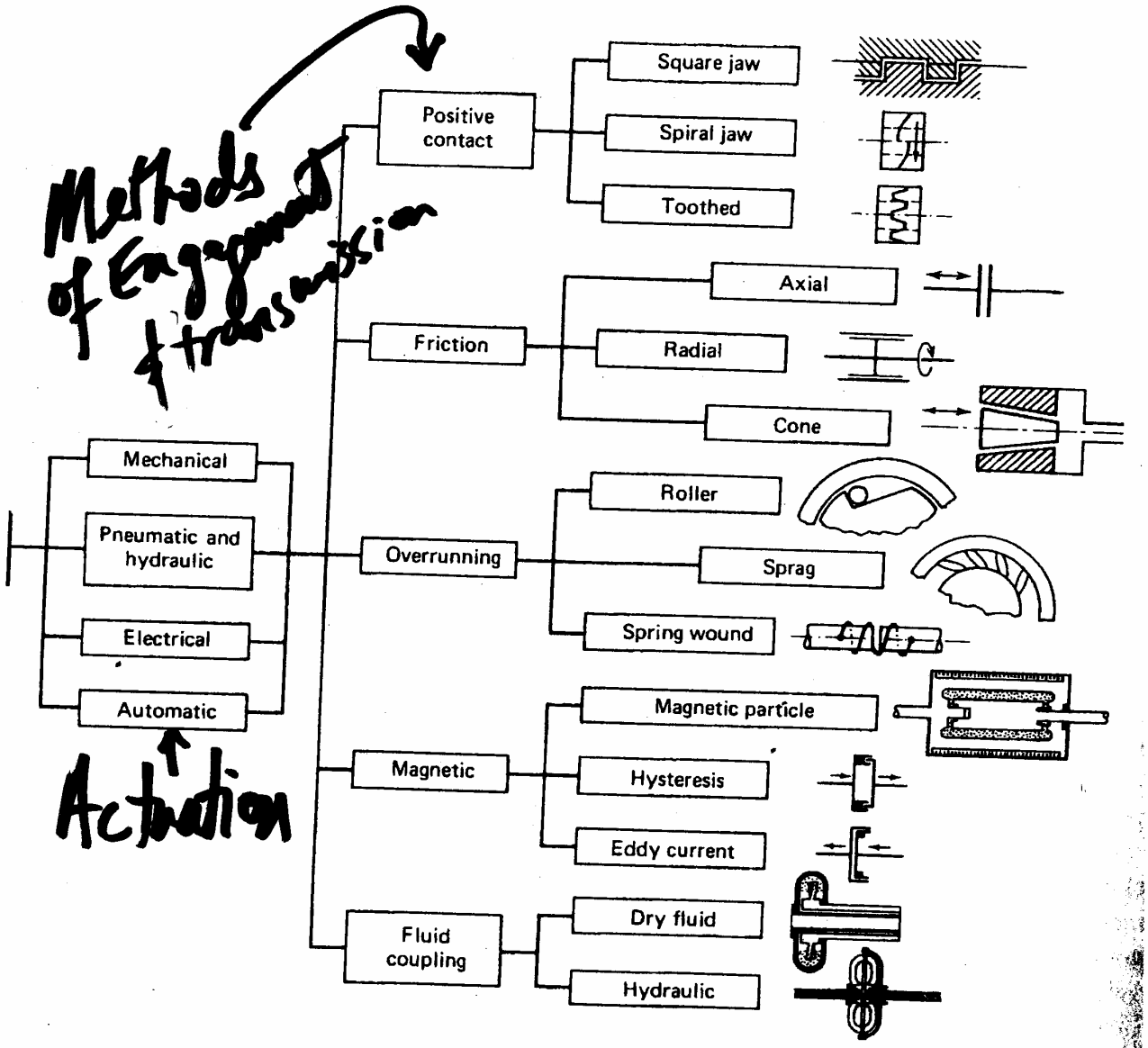


itches and Brakes *Source: U. Hunhede et al., Machine Design Fundamentals, Prentice-Hall, 1983, with permission*

Methods of Actuation & Engagement of Brakes, Clutches, etc

BRAKES & CLUTCHES
(FRICTION)

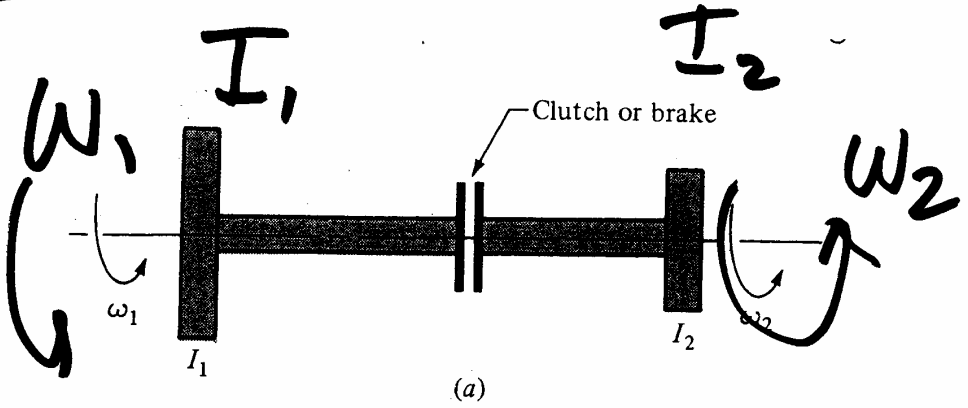
Brakes dissipate energy

... often at very high rates e.g. 1000hp sometimes for cars!

Clutches

... transfer motion between components at same and different speeds

CONCEPT



(a)

BRAKE $|\omega_1| > 0 \quad \omega_2 = 0$

$\omega_1 \Rightarrow 0$ over time

CLUTCHES

$|\omega_2| > 0 \simeq$ const

$\omega_1 \neq \omega_2$

$\omega_1 \Rightarrow \omega_2$

Interested in:

- actuating forces
- transmitted torques
- energy dissipated
- temperature rise

.... Friction

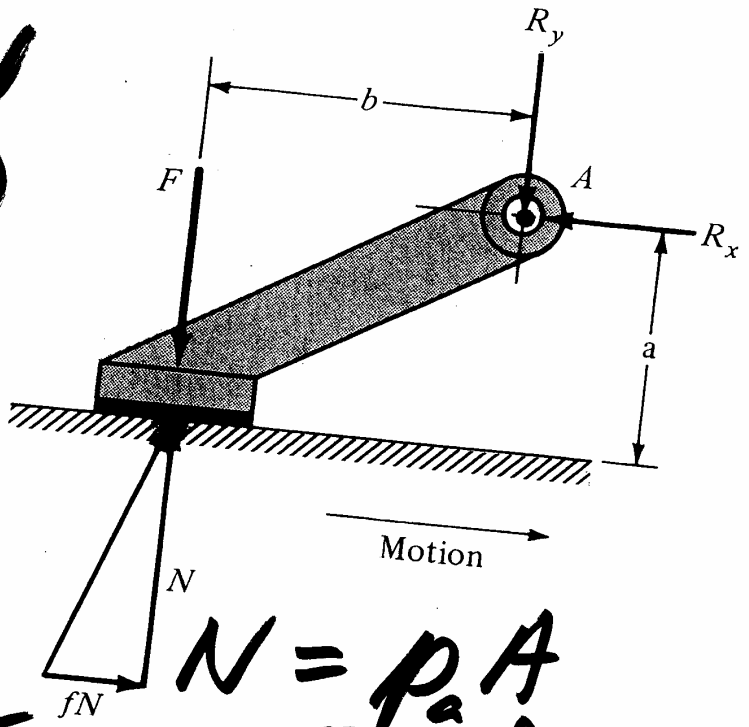
.... Wear

.... Mechanics

.... Other mtl props

Self-actuation idea

(Most/y used in BRAKES)



$N = p_a A$

f = fric coeff. p = press A = area of pad

From $\sum \vec{F} = 0$ & $\sum M_A = 0$

$$F = \frac{p_a A(b - fa)}{b}$$

if $fa > b \Rightarrow$ self actuating ($F < 0$)

"DRUM" BRAKE"

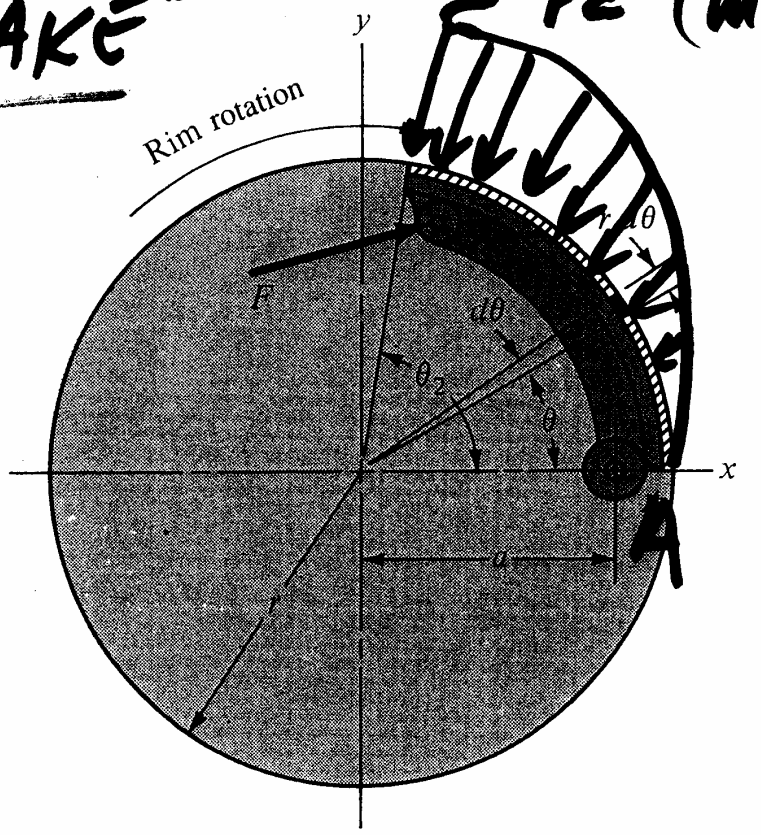
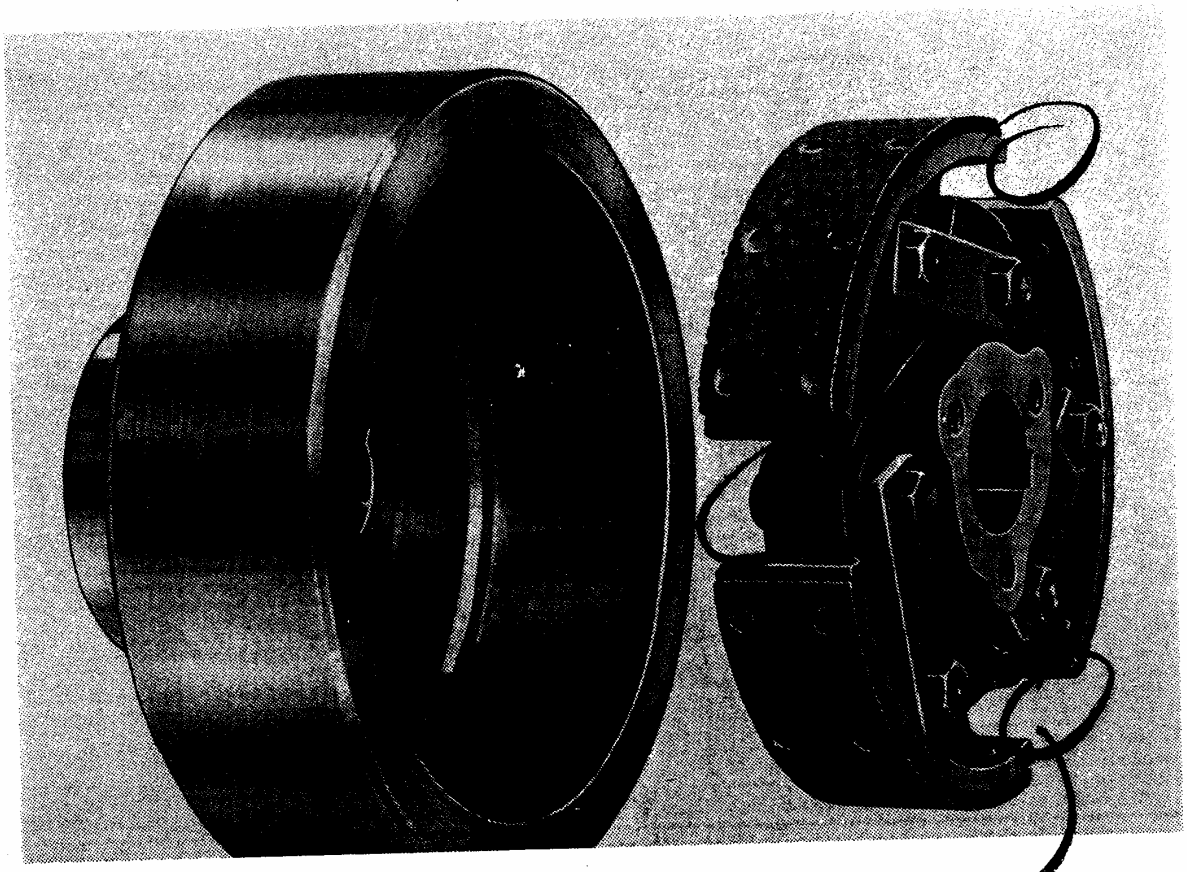
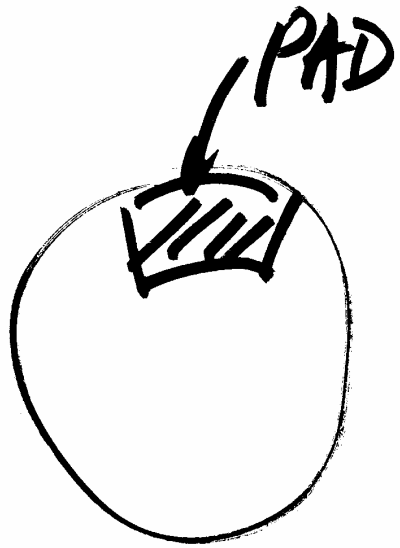


FIGURE 16-4
Internal friction shoe.

- Pressure distribution not uniform in This and Other cases
- Part near A not effective
- Some self-actuation effect.... depends on f.



Example .... areas
That would not
provide effective
braking anyway
.... Drum brakes have
large friction surfaces.



- Need more force
- Smaller friction area

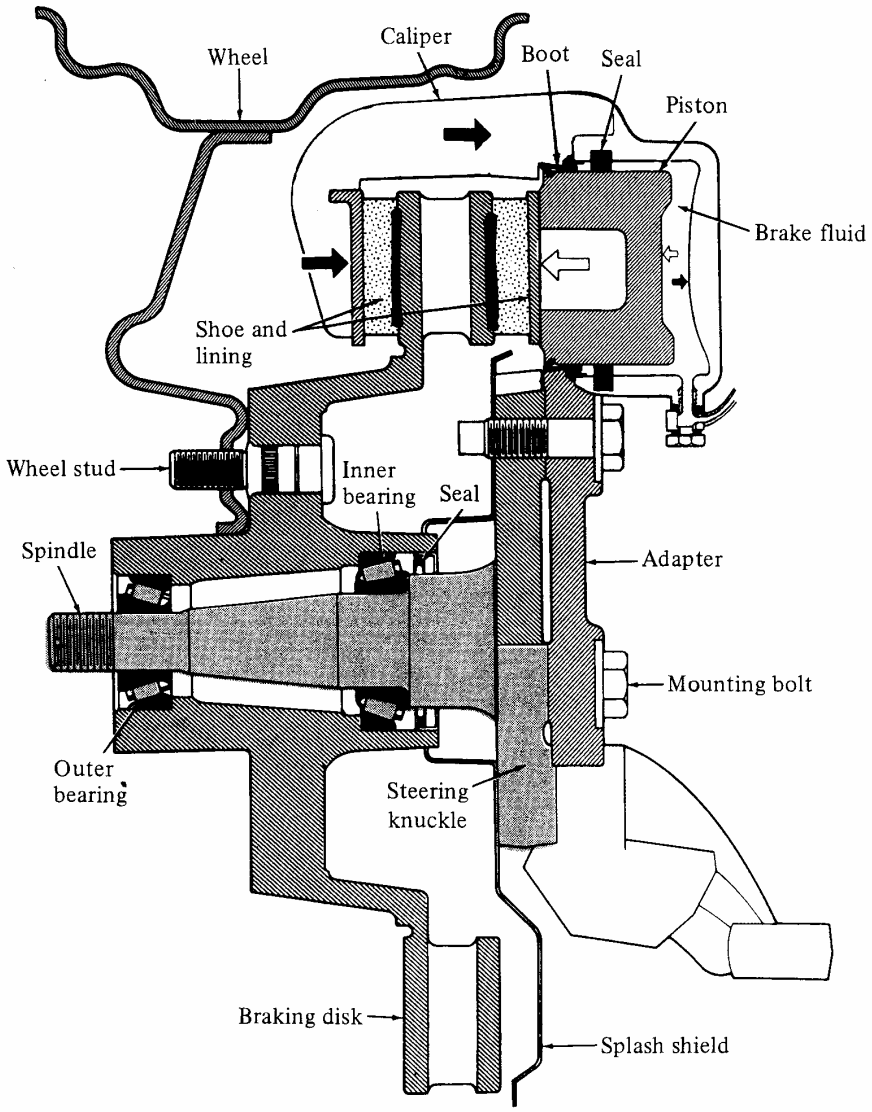


FIGURE 16-15

An automotive disk brake. *(Courtesy of Chrysler Corporation.)*

over the area of the friction pads. The seal and boot of Fig. 16-15 are designed to obtain clearance by backing off from the piston when the piston is released.

CLUTCHES

- Usually contacting discs... one or more interfaces.
- Slip times can be very short (≈ milliseconds for auto A/C compressor) or longer (≈ 1 sec) for power train clutches.
- torque capacity & wear are key .... if loss of friction... slip times & wear increase

TWO INTERFACES

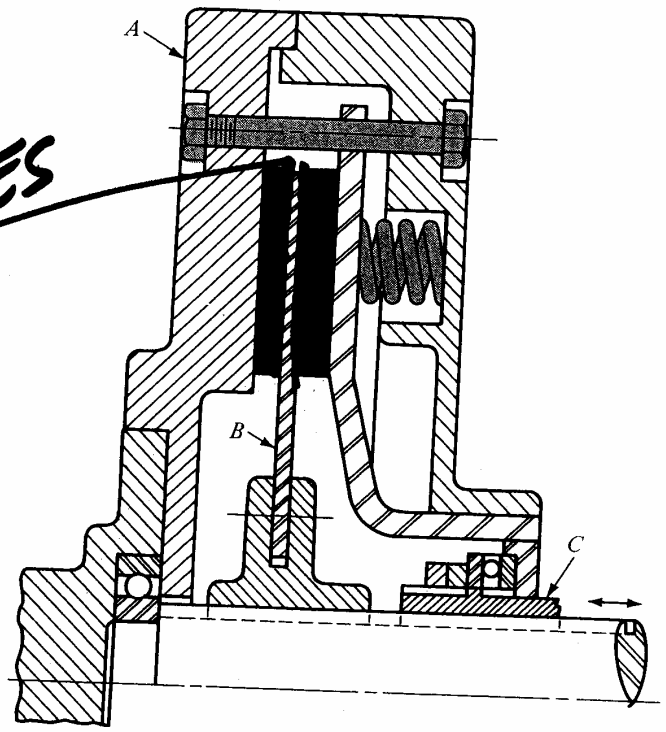
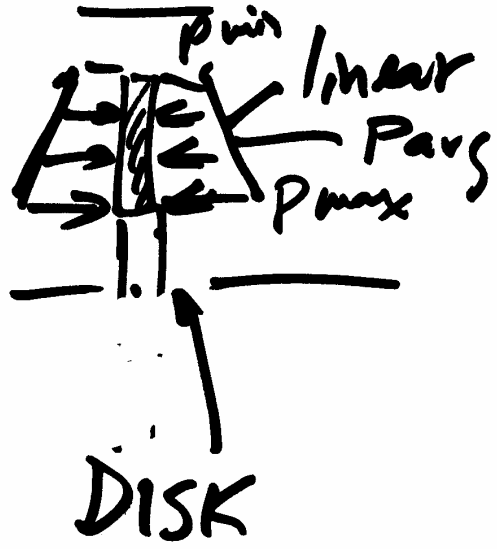


FIGURE 16-12

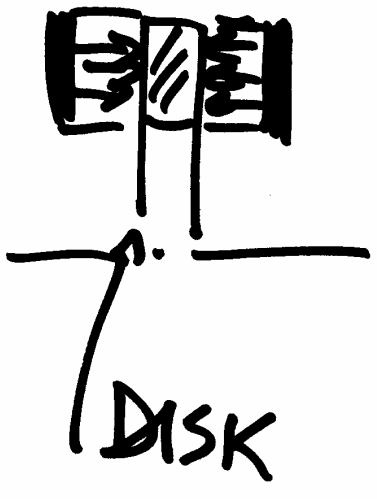
Cross-sectional view of a single-plate clutch; *A*, driver; *B*, driven plate (keyed to driven shaft); *C*, actuator.

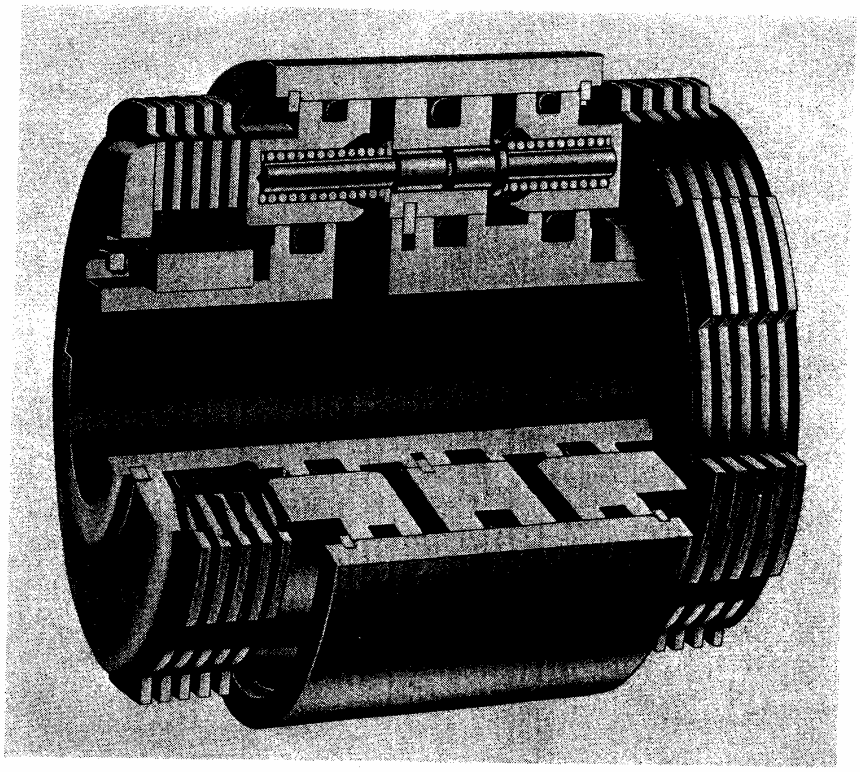
Two types of pressure distribution

UNIFORM WEAR



UNIFORM PRESSURE





CLUTCH MTLS

MATERIAL	FRICTION COEFFICIENT WET	FRICTION COEFFICIENT DRY	MAX. TEMPERATURE °F	MAX. TEMPERATURE °C	MAX. PRESSURE psi	MAX. PRESSURE kPa
Cast iron on cast iron	0.05	0.15–0.20	600	320	150–250	1000–1750
Powdered metal* on cast iron	0.05–0.1	0.1–0.4	1000	540	150	1000
Powdered metal* on hard steel	0.05–0.1	0.1–0.3	1000	540	300	2100
Wood on steel or cast iron	0.16	0.2–0.35	300	150	60–90	400–620
Leather on steel or cast iron	0.12	0.3–0.5	200	100	10–40	70–280
Cork on steel or cast iron	0.15–0.25	0.3–0.5	200	100	8–14	50–100
Felt on steel or cast iron	0.18	0.22	280	140	5–10	35–70
Woven asbestos* on steel or cast iron	0.1–0.2	0.3–0.6	350–500	175–260	50–100	350–700
Molded asbestos* on steel or cast iron	0.08–0.12	0.2–0.5	500	260	50–150	350–1000
Impregnated asbestos* on steel or cast iron	0.12	0.32	500–750	260–400	150	1000
Carbon graphite on steel	0.05–0.1	0.25	700–1000	370–540	300	2100

*The friction coefficient can be maintained within ±5 percent for specific materials in this group.

MOLDED COMPOSITES (asbestos etc)

POWDERED METAL

POWDERED METAL + CERAMICS } WEAR RESISTANT

CARBON GRAPHITE → LONG HAUL AIRCRAFT

} - ALSO USED IN BRAKES
- RUN AGAINST STEELS & CAST IRONS

IMPORTANCE OF FRICTION CONTROL

Last assignment

- Available outside Room 412 Bonner on Friday May 2

Other

- Some old exam questions will be posted on website (by Friday)
- I will hold office hrs Wed May 7 10-12 am.

Final Exam

- Three pages of notes
  - ... previous two + one more
- Open book
- Comprehensive
  - ... 3 hrs
  - ... 6 questions
  - ... 30%-50% from mtl since last test
- KNOX 109 Thurs May 8 3:30-6:30 pm.

Additional material for Final

(beyond Test 2)

- Journal bearings → Ch 12
- Ball bearings → Ch 11
- Spur gears → Ch 13, 14

Ch 12

Journal Bearings

12-1 to 12-10 } Nothing from other sections
12-13, 12-16 }

- ... Use of design graphs
- ... Max W or Min f designs
- ... iteration ... making reasonable initial estimates of μ, ℓ/d or whatever
- ... design guidelines from notes
- ... understand T_{av}, T_1, ΔT

Hit one problem guaranteed

Ch 11

Ball bearings

11-1 - 11-3 $C = FL^{1/a}$

ϕ (L_{10} life)

11-6 Ball bearing selection

(11-10 Descriptive only)

Ch 13, 14 Gears

(1) 13-1 to 13-7 and 13-12 Tooth Geometry

(2) 13-13 Gear trains; simple & compound

(3) 13-14 Gear Forces & bearing forces

(4) 14-1, 14-2 & notes *** Sizing of spur gears ... bending & surface durability