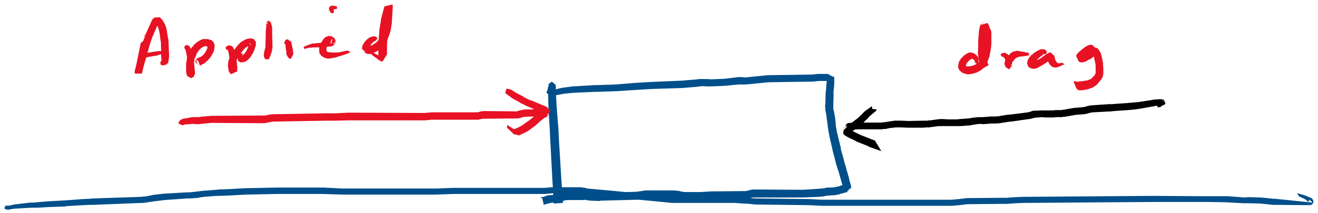
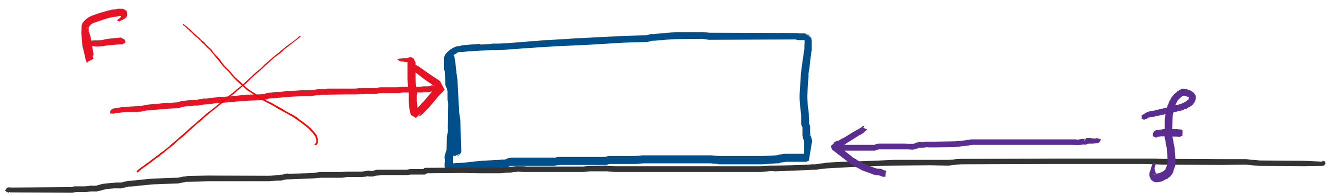
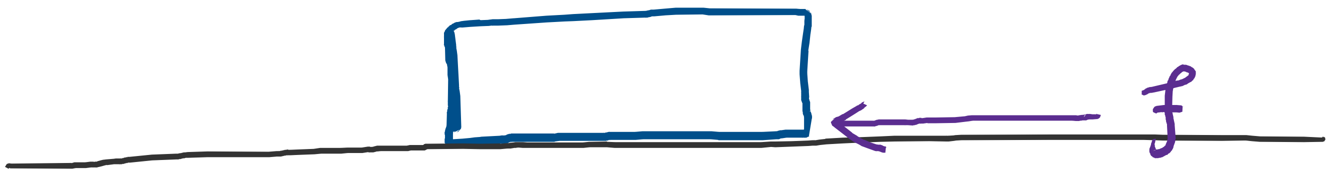
Drag forces

- These are forces that resist motion
- They always act in opposite direction to the applied force

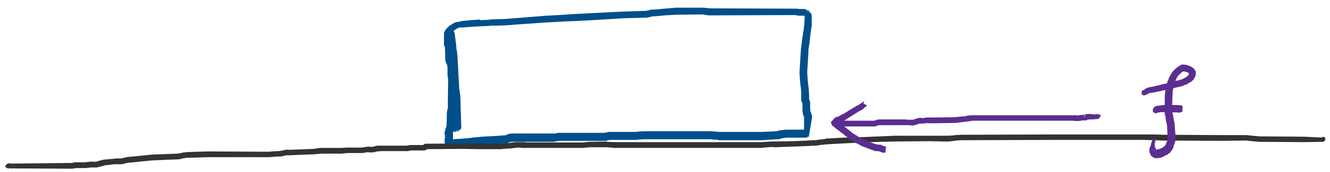




If you removed the forward force F, you will remain with f.



- If you removed the forward force F, you will remain with f.
- Why then doesn't the object start moving backward because there is an unbalanced force is to the left?
-



- If you removred the forward force F, you will remain with f.
- Why then doesn't the object start moving backward because the unbalanced force is to the left?
- If this was the case, all objects would be moving on their own without being pushed because there us already f acting.

Then why don't they move backwards because of the unbalanced force ?

Then why don't they move backwards because of the unbalanced force ?

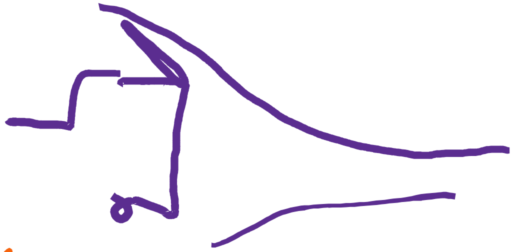
It is because of the way drag works.

Drag only appears when there is motion

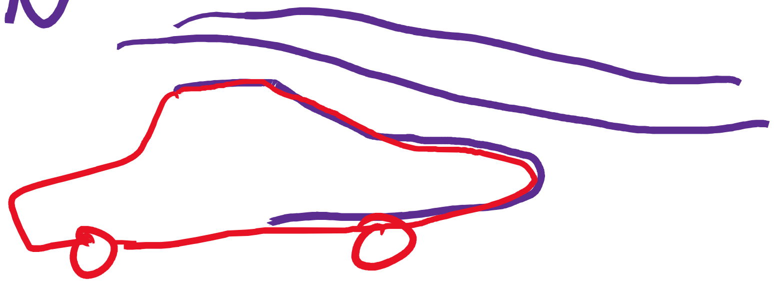
Drag

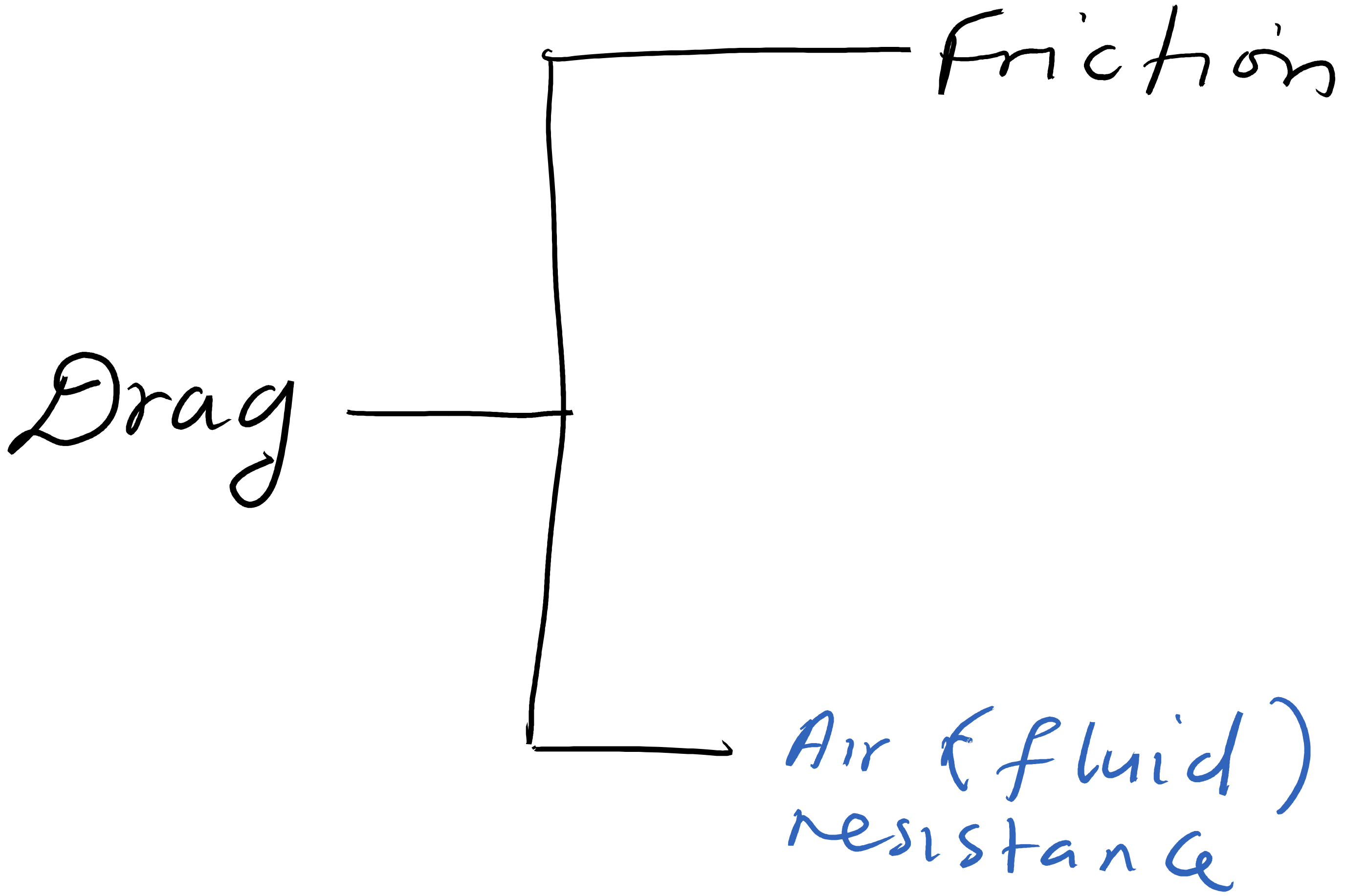
Friction – depends on the roughness of the two surfaces in contact

Air resistance (fluid) – depends on the speed of the moving object ∝ Shape



$\hat{F}_D \propto v^2$




Drag
Friction
Air (fluid) resistance

Drag

- Friction
  - Depends on the roughness of the surfaces in contact
- Air (fluid) resistance

Drag

- Friction
- Air (fluid) resistance

Depends on the Speed and Shape of the moving object

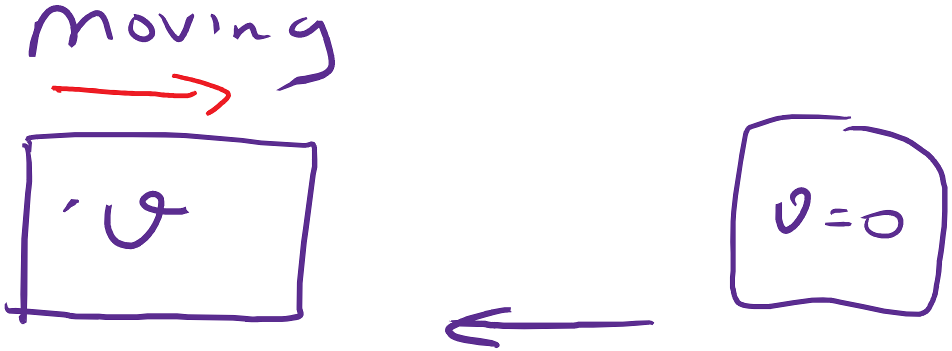
$$F_D = \frac{1}{2}\rho v^2 C_D A$$

FRICTION

- Its everywhere around us
- Indespensable factor in the ability of 'animals' to move
- Without friction, an object that is pushed into motion could continue in motion forever. (N-1st law)

FRICTION

- Its everywhere around us
- Indespensable factor in the ability of 'animals' to move
- Without friction, an object that is pushed into motion could continue in motion forever. (N-1st law)
- friction dissipates kinetic energy (KE) into heat & eventually stops the moving object



KE → Thermal energy (TE)

KE = TE if all the KE is converted to TE

- can produce undesirable wear & tear an destructive heating on contact surface

- It can be nuisense sometimes (undesirable)

Desired	Undesired

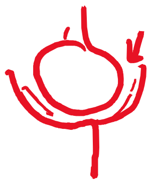
- Can produce undesirable wear & tear an destructive heating on contact surface

- It can be nuisense sometimes (undesirable)

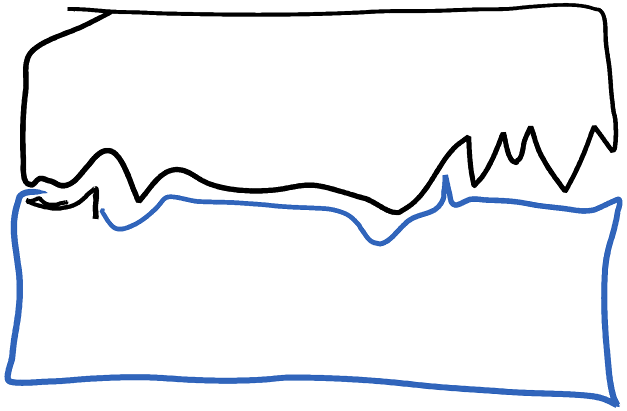
Desired	Undesired
- walk	- eye - eyelid - cornea
- Scrabbing	- joints 
- grip	- Engines

- Nature & Engineers tend to maximise friction where it is necessary & minimise where it is undesirable.

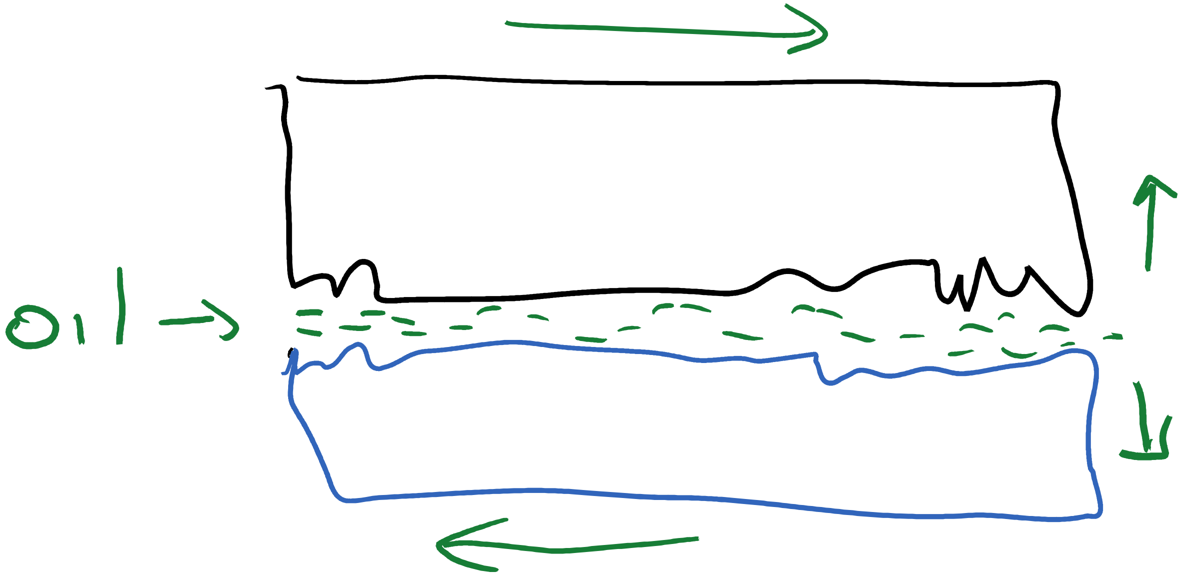
Nature —— make our own thing | oils, grease



Synovial fluid ——



Lubrication



Mechanism of friction

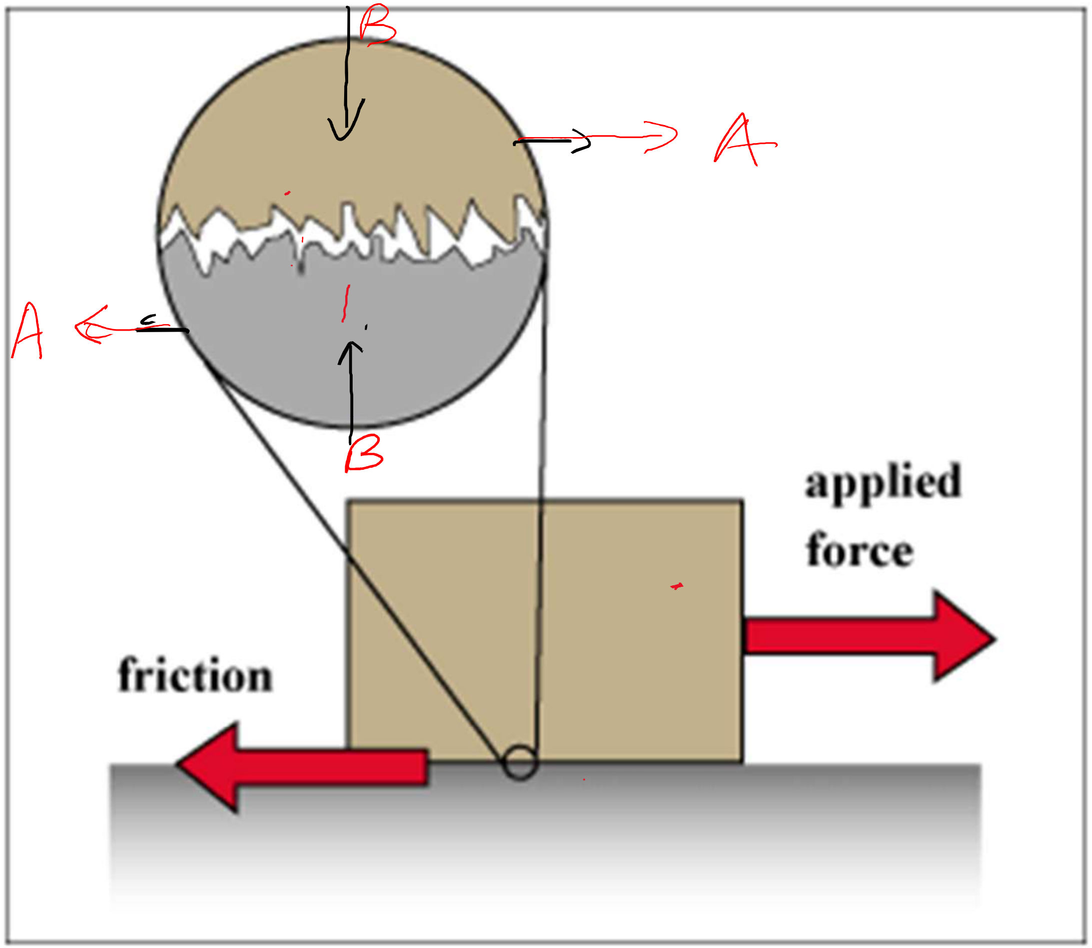
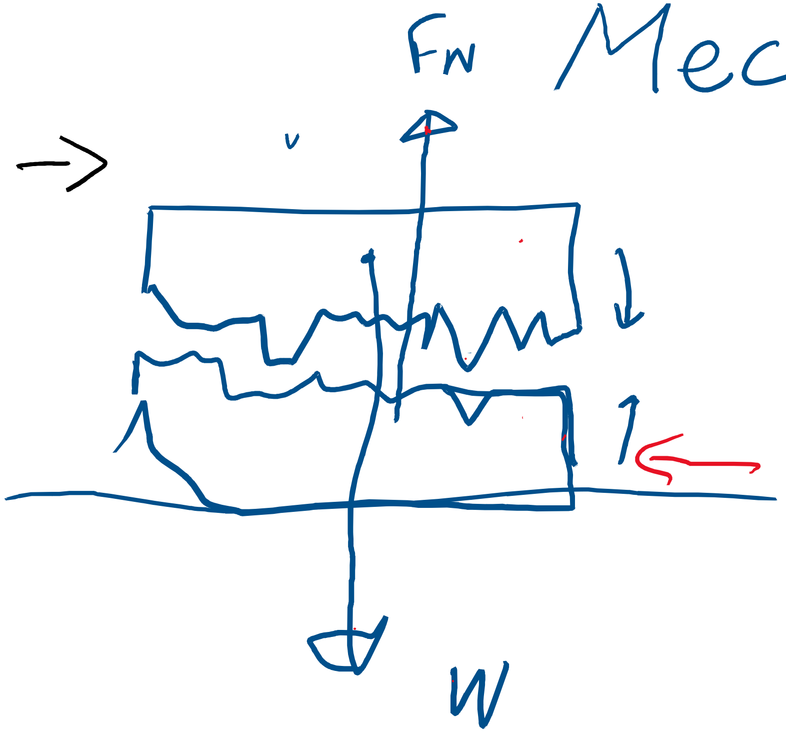


Fig. 2-4 Friction arises from the very small irregularities on the surfaces in contact.

Fig. 2-5 Rubber strips on staircases help to increase friction and prevent slippery.

Mechanism of friction



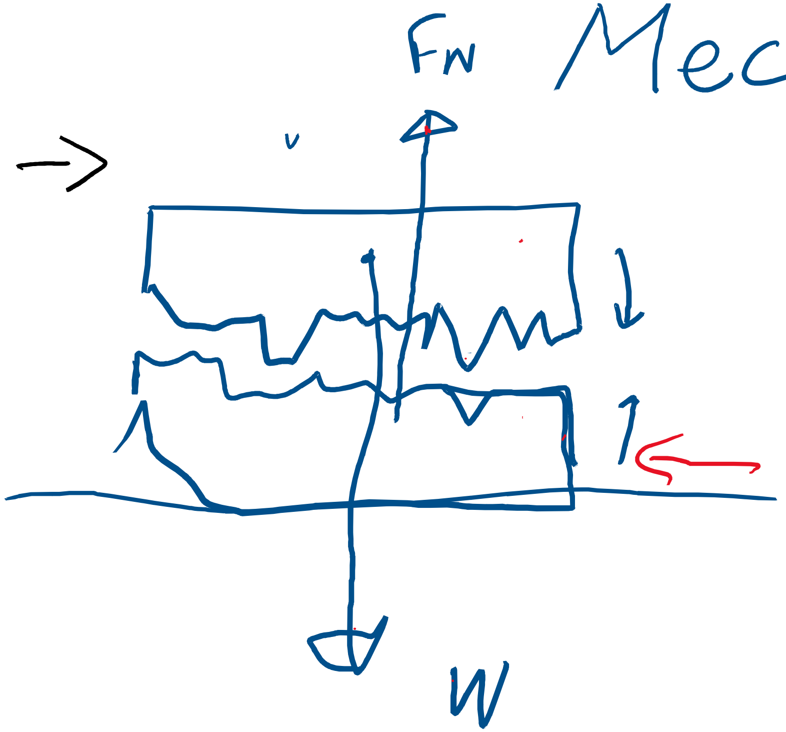
$$\sum F = 0$$

$$F_N + (-W) = 0$$

$$F_N = W = mg$$

f is dependent on the force compression

Mechanism of friction



$\Sigma F = 0$

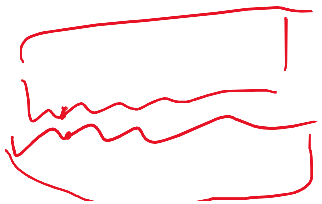
$F_N + (-W) = 0$

$F_N = W = mg$

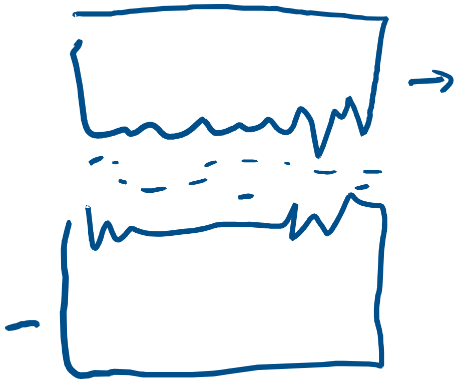
f is dependent on the force Compression

- For friction to exist, the ridges & troughs have to interlock so that it becomes hard for surfaces to rub against each other.

When two surfaces move over each other the roughness makes it more difficult to rub against each other.



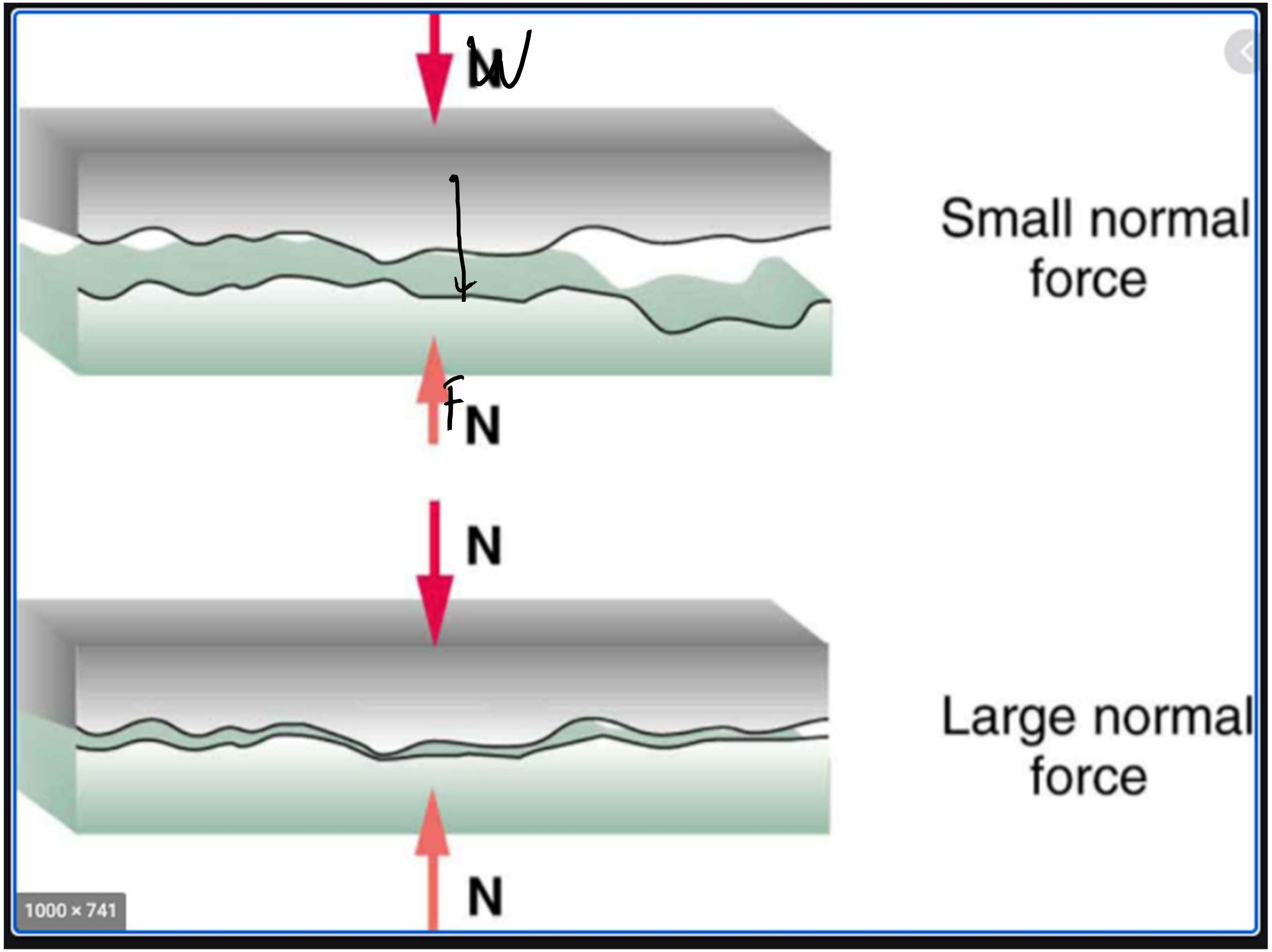
- When oil (fluid) is placed between the 2-surfaces, it pushes them apart thereby reducing the frictional force



lubrication

(FN)

- friction depends on the compression force that presses the two surfaces together. This force is the reaction normal force



W
Small normal force
F N
N
Large normal force
N
1000 × 741

Types of friction

1. Static friction – friction experienced by an object when it is just about to move

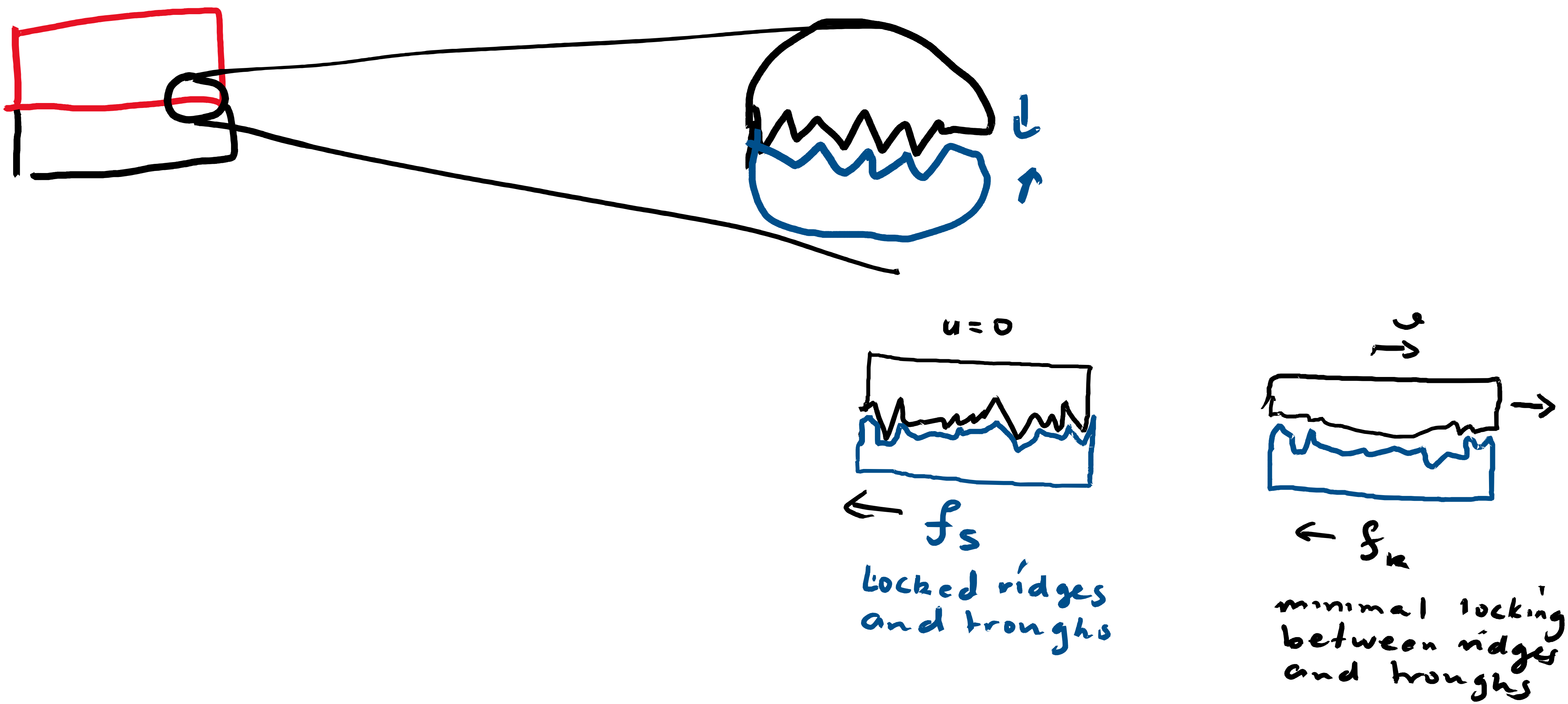
$$f_s = \mu_s F_N$$

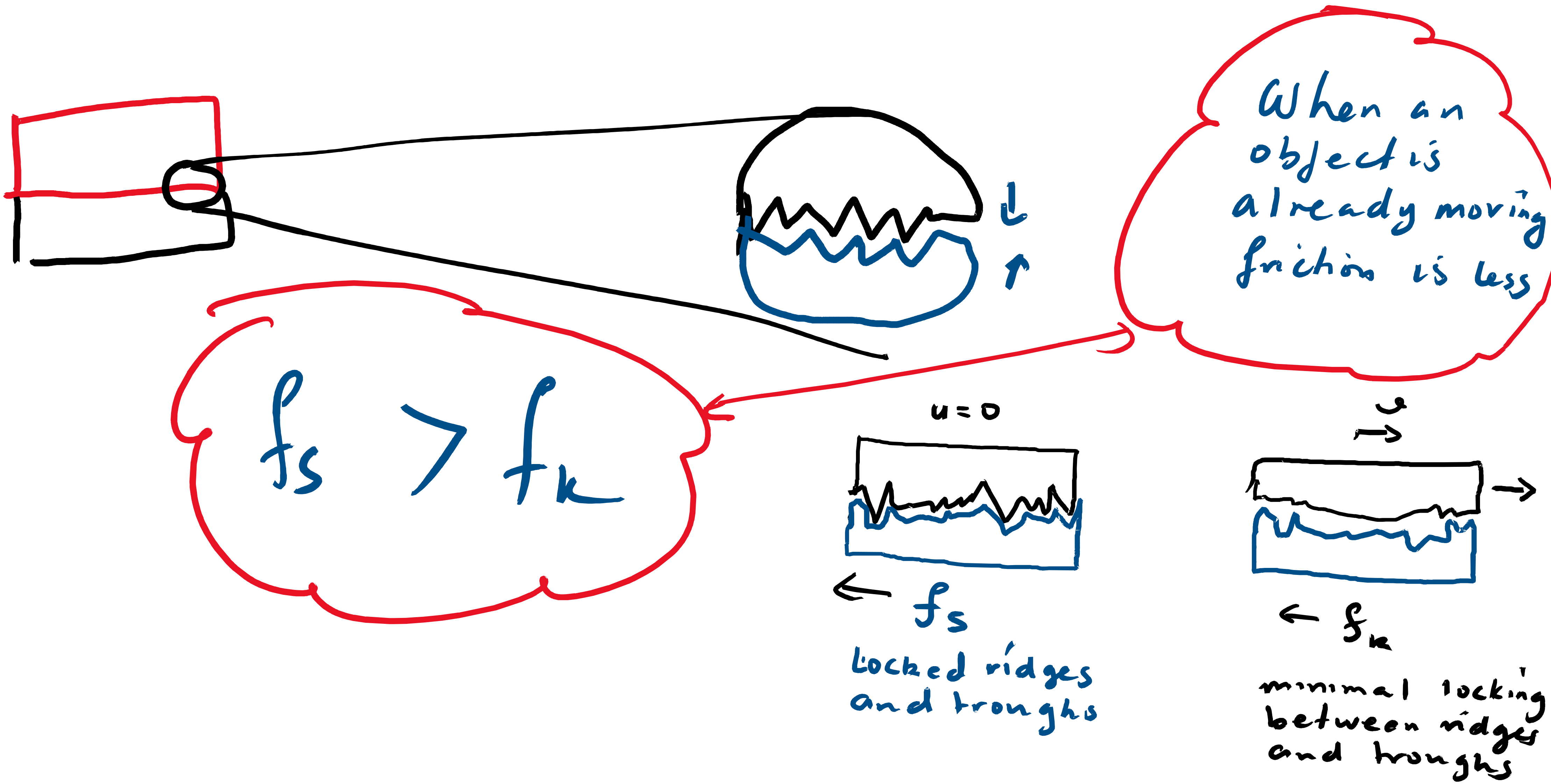
2. Kinetic friction – friction experienced by an object in motion.

$$f_k = \mu_k F_N$$

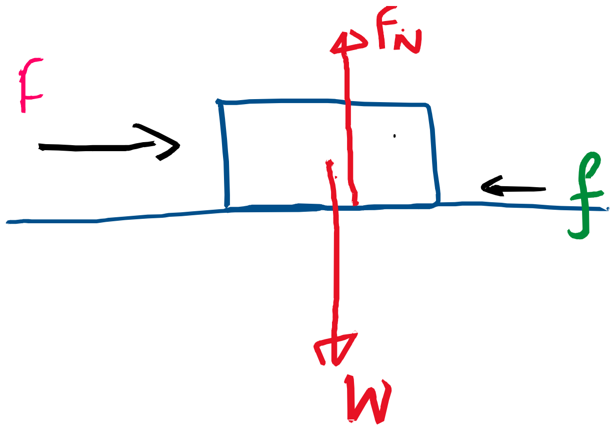
By the way

$$f_s > f_k$$


u = 0
f_s
Locked ridges and troughs
v
f_k
minimal locking between ridges and troughs



When an object is already moving friction is less
$f_s > f_k$
u = 0
f_s
Locked ridges and troughs
v
f_k
minimal locking between ridges and troughs



Since there is no motion in the y dir, by N- 1st law

$$\sum F_y = 0 : \quad F_N + (-W) = 0$$

$$F_N = W = mg$$

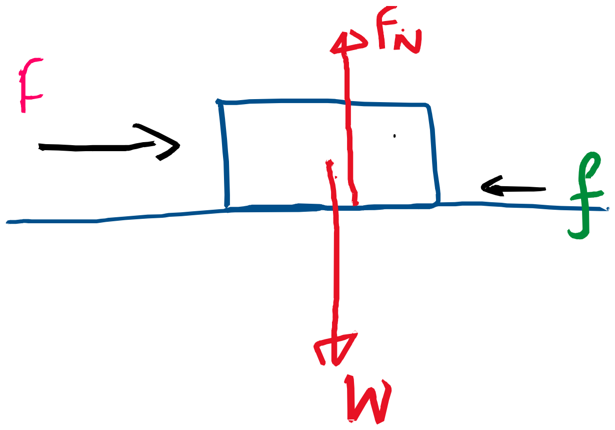
Thus $\boxed{f = \mu F_N} = \mu mg$

$\mu \equiv$ Coefficient of friction : Its value $0 \leq \mu \leq 1$

$0 \longrightarrow 1$

F_N = normal force or Compressive force

$$\mu = \begin{cases} 0 & \text{— smooth} \\ \vdots & \text{-- rough} \\ 1 & \text{- max. possible friction} \end{cases}$$



Since there is no motion in the y dir, by N- 1st law

$\sum F_y = 0$: $F_N + (-W) = 0$

$F_N = W = mg$

In short

$\sum F_\uparrow = \sum F_\downarrow$

$F_N = W$

Thus $\boxed{f = \mu F_N} = \mu mg$

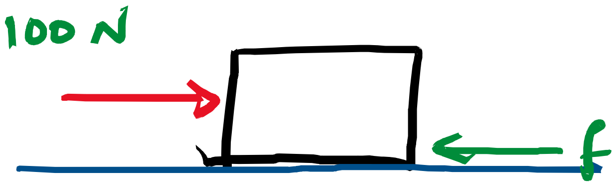
$\mu \equiv$ coefficient of friction : Its value $0 \leq \mu \leq 1$

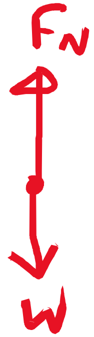
$0 \longrightarrow 1$

F_N = normal force or Compressive force

$$\mu = \begin{cases} 0 & \text{— smooth} \\ \vdots & \text{-- rough} \\ 1 & \text{- max. possible friction} \end{cases}$$

Ex: A 5 kg box is being pushed as shown. If the coefficient of friction between the box and the table is 0.2, find the friction and acceleration in each case.



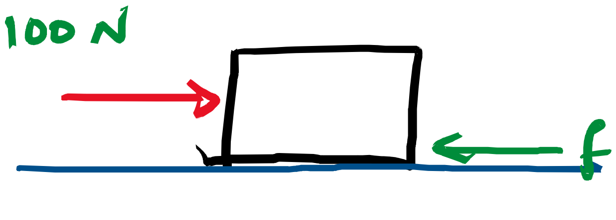


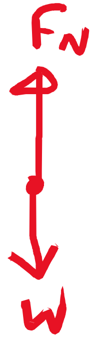
$$\Sigma F_\uparrow = \Sigma F_\downarrow$$

$$F_N = W$$
$$= mg$$
$$= 5 \times 9.8$$
$$= 49\,N$$

$$f = \mu F_N$$
$$= 0.2(49)$$
$$= \underline{9.8\,N}$$

Ex: A 5 kg box is being pushed as shown. If the coefficient of friction between the box and the table is 0.2, find the friction and acceleration in each case.





$$\Sigma F_\uparrow = \Sigma F_\downarrow$$

$$F_N = W$$

$$= mg$$

$$= 5 \times 9.8$$

$$= 49\text{ N}$$

$$f = \mu F_N$$

$$= 0.2\,(49)$$

$$= 9.8\text{ N}$$

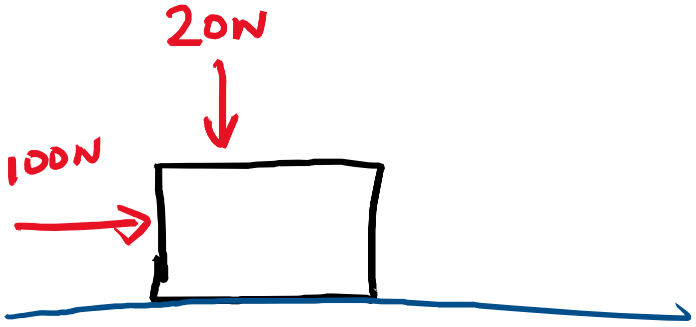
acceleration?

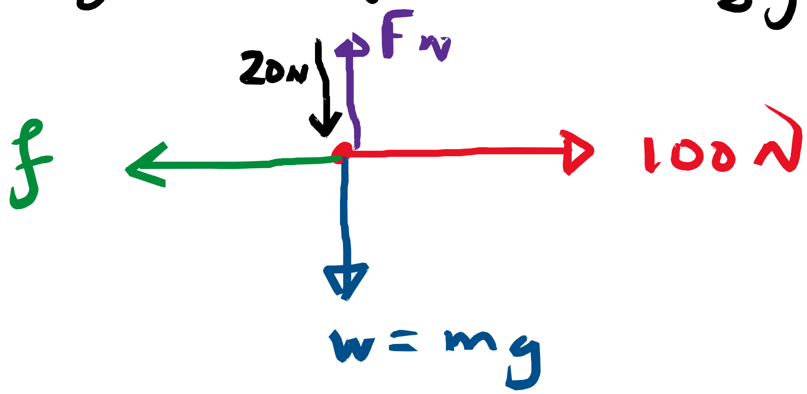
$$F_{net} = ma$$

$$(100 - 9.8) = 5\,(a)$$

$$a = 18.0\text{ m/s}^2$$

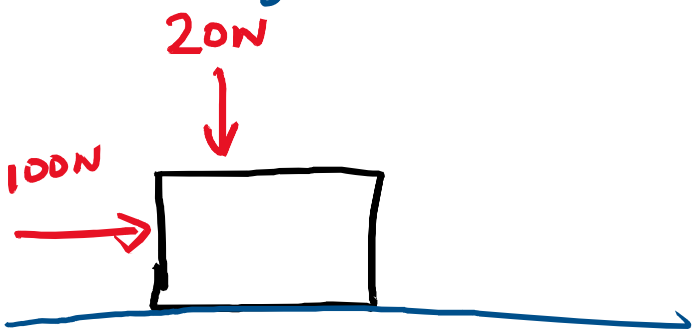
Ex. Calculate the friction and acceleration for the system below. mass of the object = 5 kg, $\mu = 0.2$

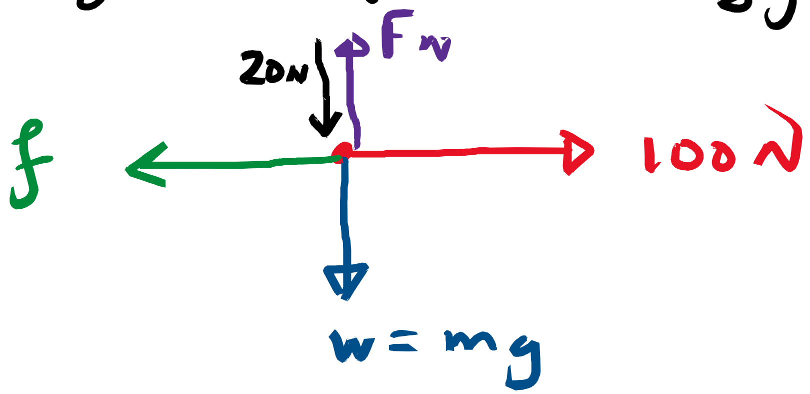




$$f = \mu F_N$$

Ex. Calculate the friction and acceleration for the system below. mass of the object = 5 kg, $\mu = 0.2$





$f = \mu F_N$

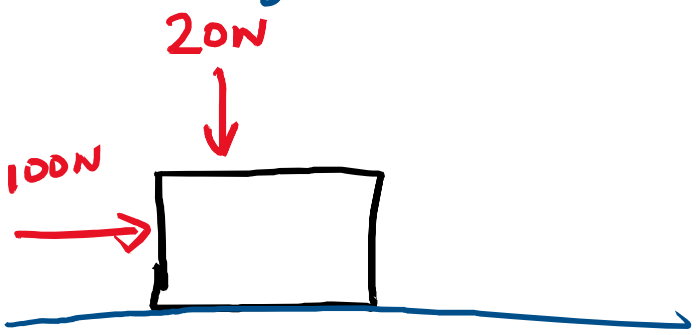
$\Sigma F_{\uparrow} = \Sigma F_{\downarrow}$

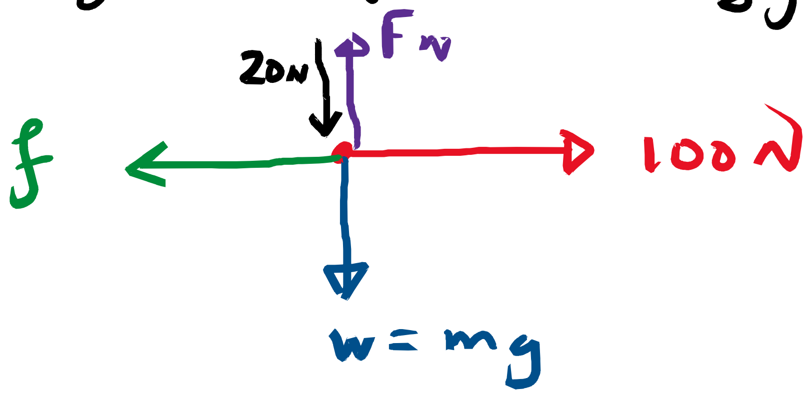
$F_N = 20 + mg$

$= 20 + 5(9.8)$

$= 69 N$

Ex. Calculate the friction and acceleration for the system below. mass of the object = 5 kg, $\mu = 0.2$





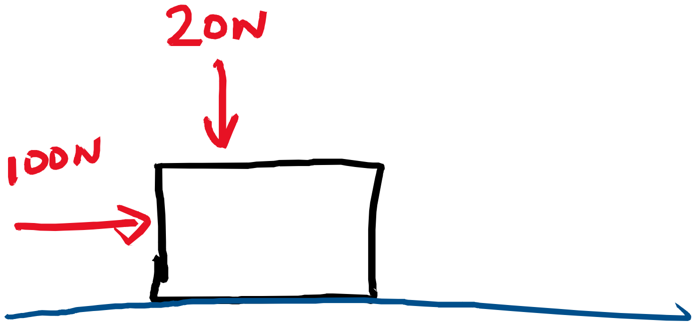
$f = \mu F_N$

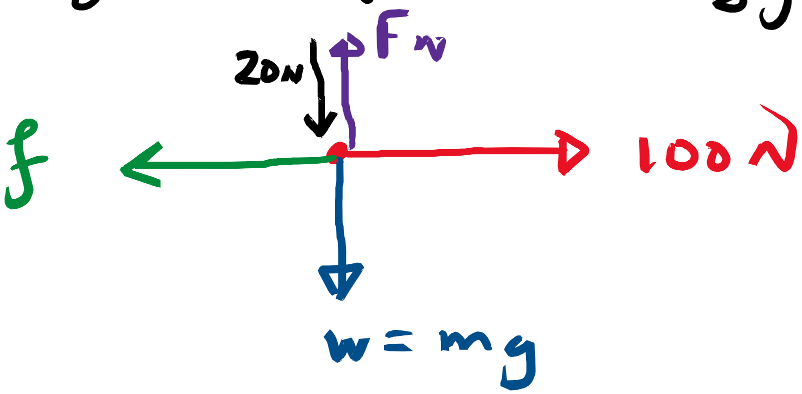
$\Sigma F_{\uparrow} = \Sigma F_{\downarrow}$

$F_N = 20 + mg$
$= 20 + 5(9.8)$
$= 69 N$

$f = \mu F_N$
$= 0.2(69)$
$= 12.8 N$

Ex. Calculate the friction and acceleration for the system below. mass of the object = 5 kg, $\mu = 0.2$





$f = \mu F_N$

$\Sigma F_\uparrow = \Sigma F_\downarrow$

$F_N = 20 + mg$

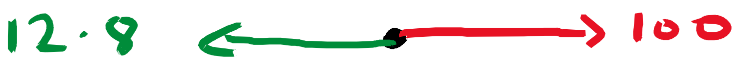
$= 20 + 5(9.8)$

$= 69N$

$f = \mu F_N$

$= 0.2(69)$

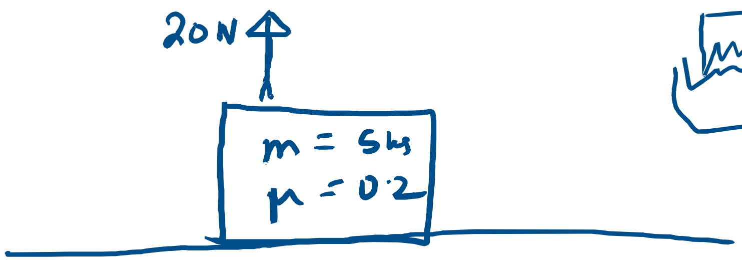
$= 12.8 N$

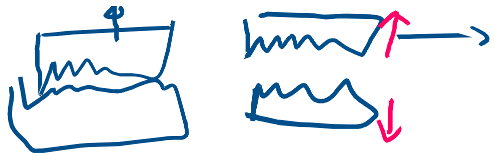


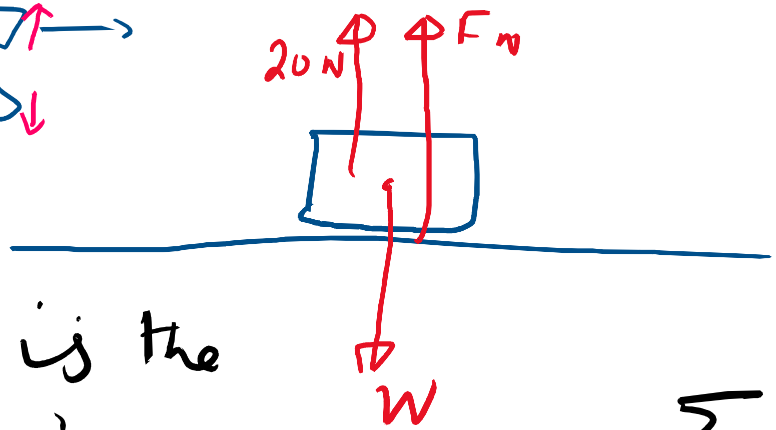
$F_n = ma$

$(100 - 12.8) = 5(a)$

$a = 17.4 m/s^2$







What is the friction?

$$f = \mu F_N$$

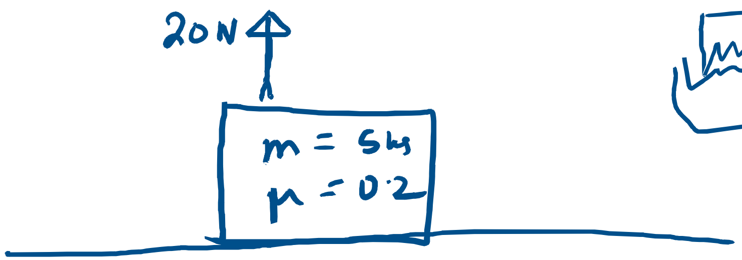
$$\sum F_{\uparrow} = \sum F_{\downarrow}$$

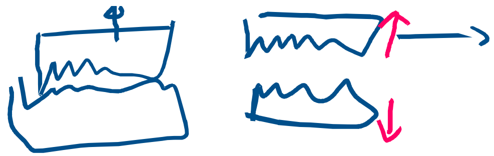
$$20 + F_N = W$$

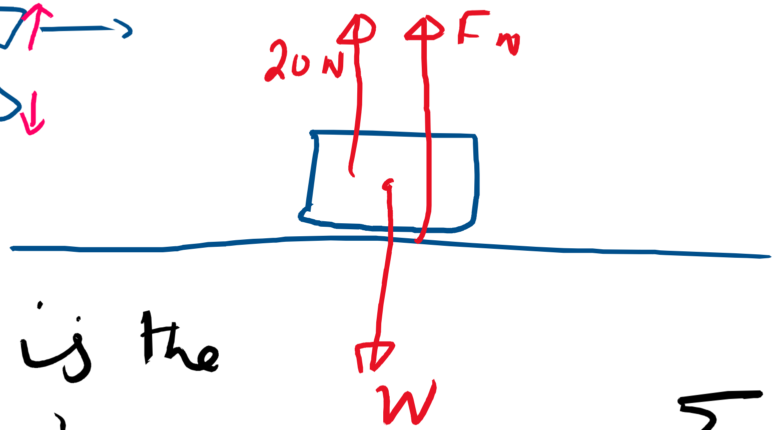
$$F_N = W - 20$$

$$= 5(9.8) - 20$$

$$F_N = 29N$$





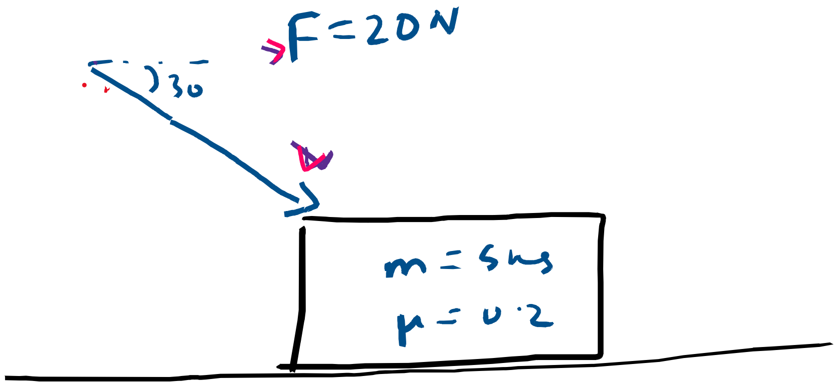


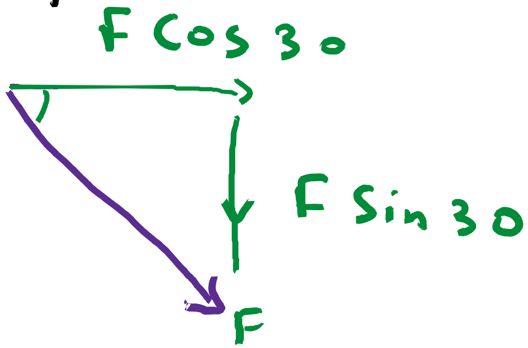
What is the friction?

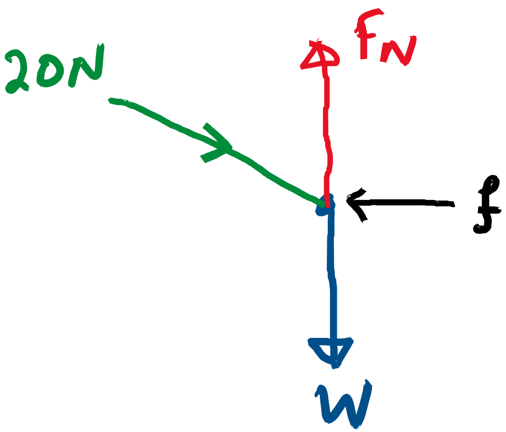
$$f = \mu F_N$$
$$= 0.2(29)$$
$$= 5.8N$$

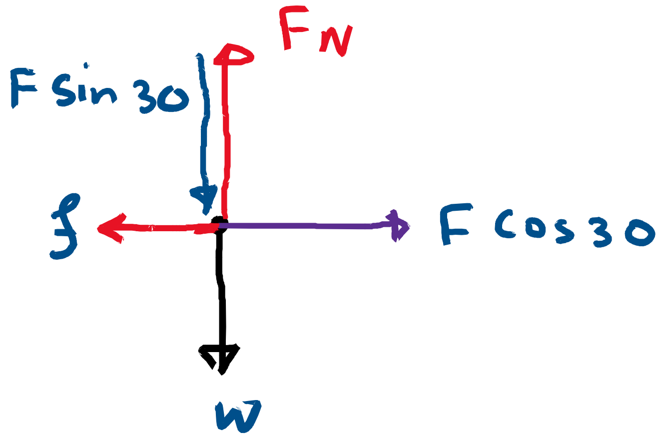
$$\sum F_{\uparrow} = \sum F_{\downarrow}$$
$$20 + F_N = W$$
$$F_N = W - 20$$
$$= 5(9.8) - 20$$
$$F_N = 29N$$

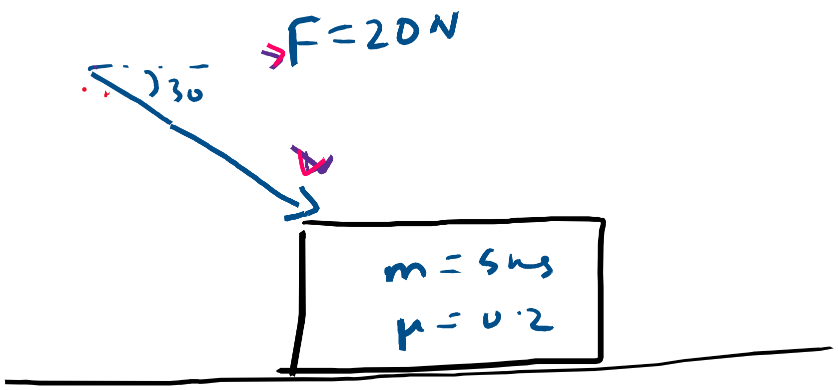
Calculate the acceleration of the object.



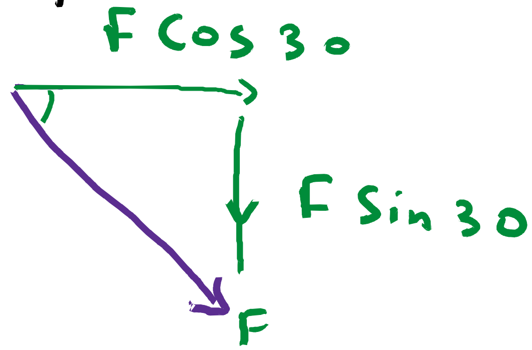


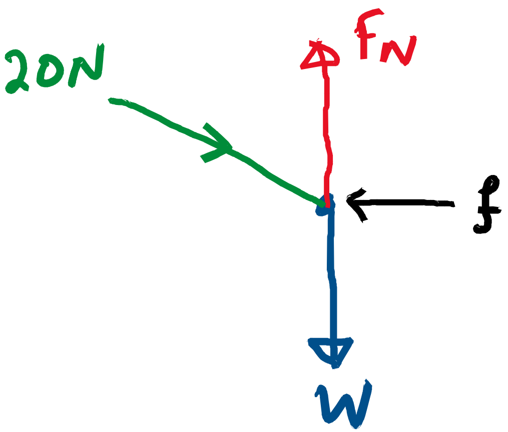


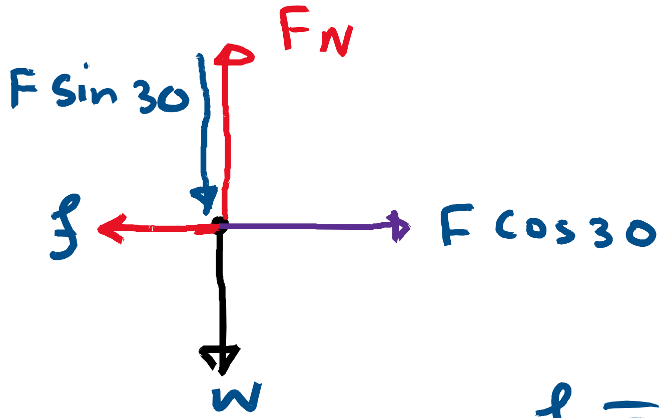




Calculate the acceleration of the object.





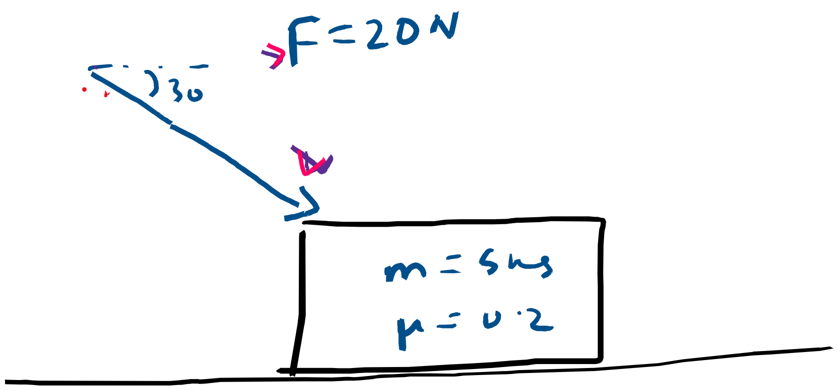


$$f = \mu F_N$$

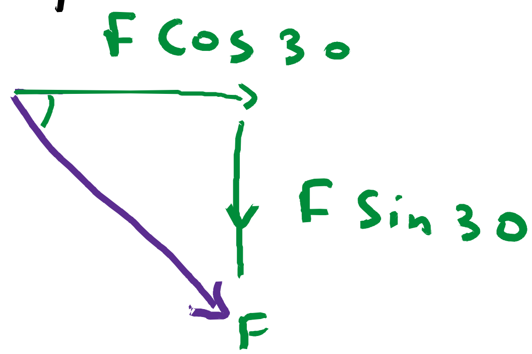
$$\Sigma F_{\uparrow} = \Sigma F_{\downarrow} : \quad F_N = F \sin 30 + W$$

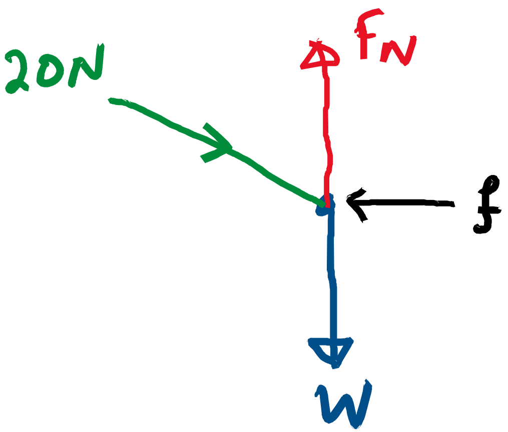
$$= 20 \sin 30 + 49$$

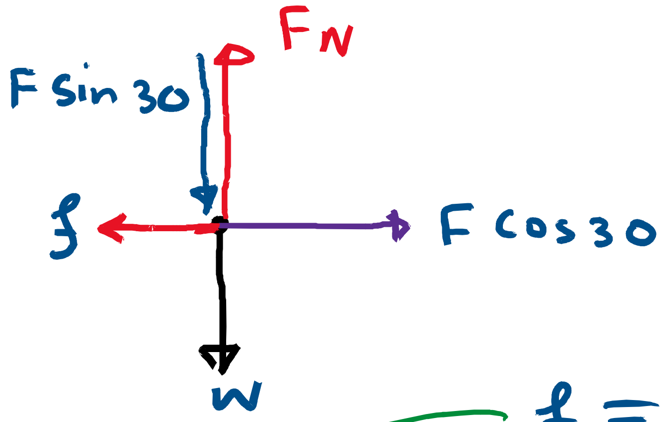
$$= 59N$$



Calculate the acceleration of the object.







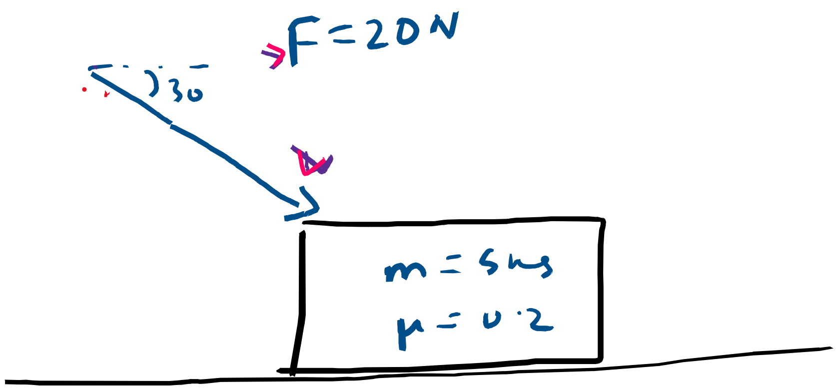
$f = \mu F_N = 0.2(59)$

$\Sigma F_\uparrow = \Sigma F_\downarrow$: $F_N = F \sin 30 + W$

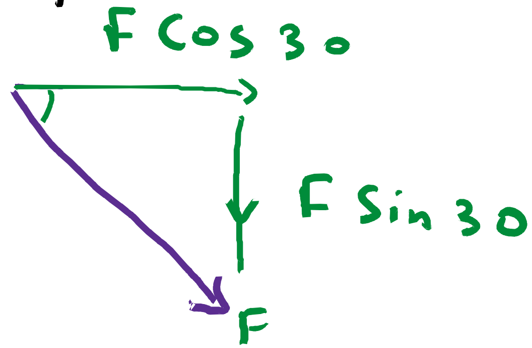
$= 20 \sin 30 + 49$

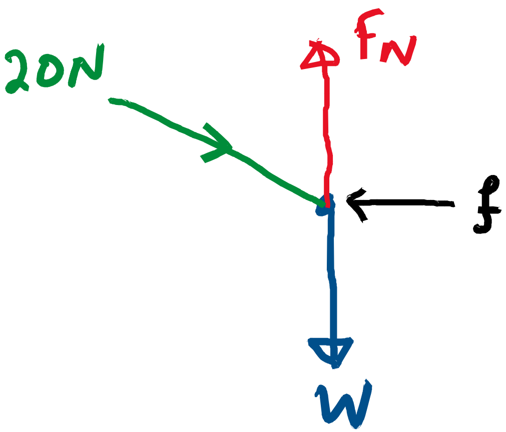
$= 59 N$

$f = 11.8 N$



Calculate the acceleration of the object.





$F_n = ma$

$17.3 - 11.8 = 5(a)$

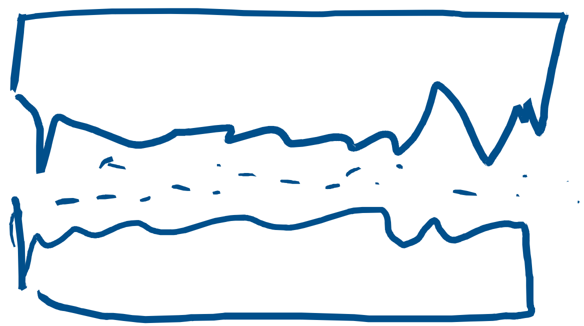
$a = 1.1 \ m/s^2$

Friction in nature

- Nature and Engineers tend to maximise friction when it is necessary and minimise when it is undesirable.

- Friction is greatly reduced by Introducing a fluid such as oil at the interfaces of the two surfaces. This is called lubrication.

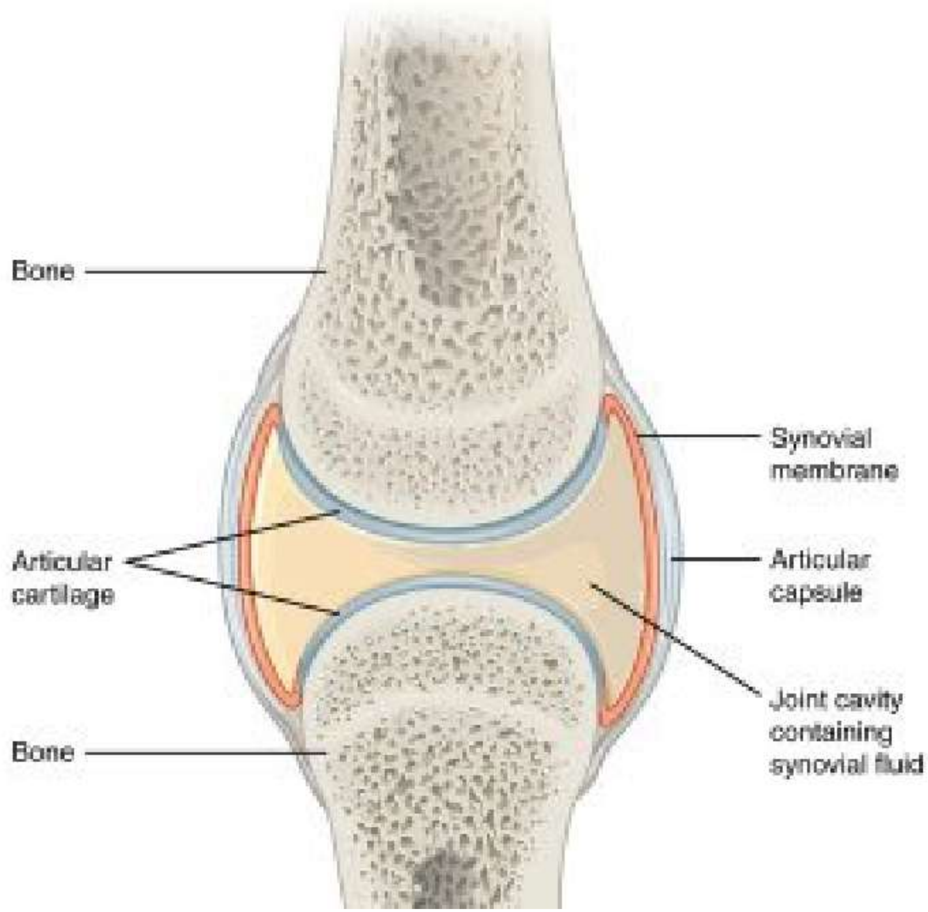
- The fluid fills the grooves and smoothens out the surfaces.



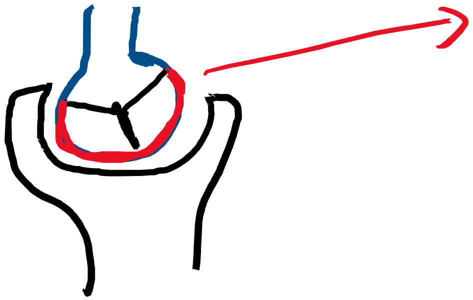
- A natural example of such lubrication is the lubrication that occurs in joints of animals which are lubricated by the synovial fluid.
- The lubricant reduces the μ by a factor of 100.
- Worn out (scarred) joints cause severe pain, a condition called athritis.

Friction at the hip joint

- The forces acting on the joints are very large.
- When the joints are in motion, these large forces produce frictional wear which could be damaging unless the joints are well lubricated.
- Frictional wear at the joints is greatly reduced by a smooth cartilage coating at the contact ends of the bone and by synovial fluid which lubricates the contact area.
- When a person walks, the full body weight rests on one leg through most of the step. Because the centre of gravity is not directly on the joint, the force on the joint is greater than the weight.

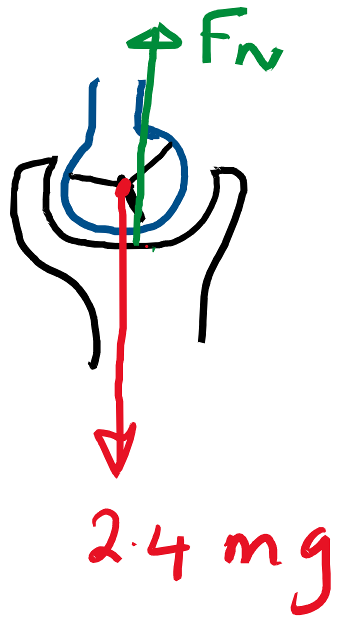


- In each step the joint rotates about 60°.
- Since the radius of the joint is about 3 cm, the joint slides about 13 cm inside the socket during each step.



$$c = \frac{2}{3}(2\pi r) \simeq 13 \text{ cm}$$

- In each step the joint rotates about 60°.
- Since the radius of the joint is about 3 cm, The joint slides about 13 cm inside the Socket during each step.



frictional force in the joint is

$$f = \mu F_N$$
$$= \mu \, 2.4 \, mg$$

The work done expended in sliding the joint against friction is

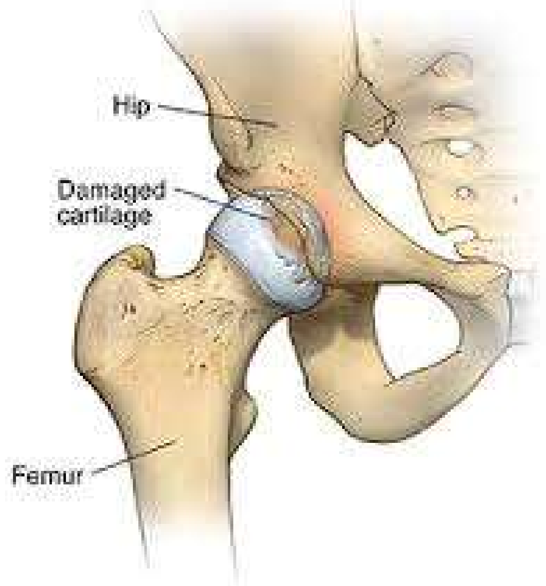
$$W = f d = \mu 2.4mg \times 0.13$$

The work is usually dissipated into heat energy.

If there is insufficient lubrication or the joints are scarred, the heat generated by friction would destroy the joint.

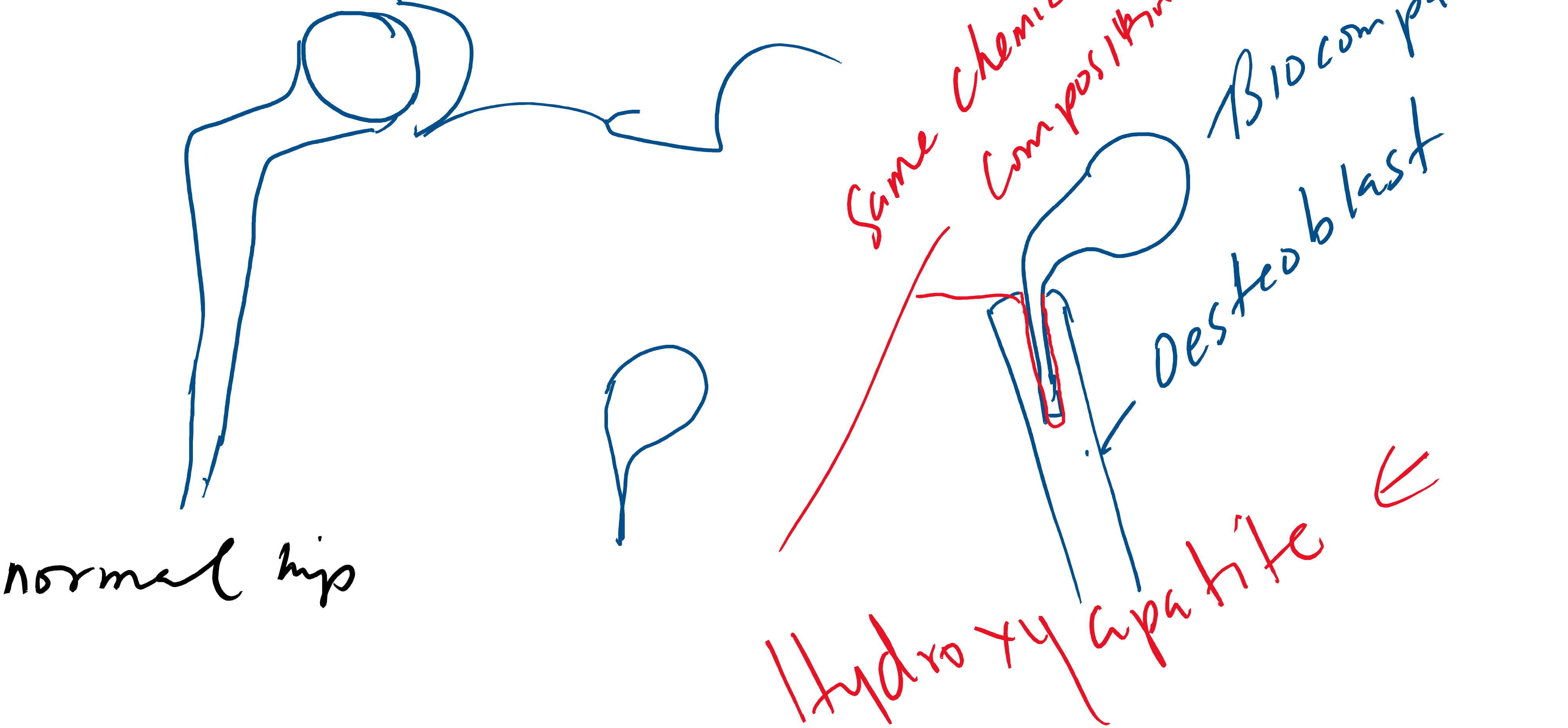
This brings hip/knee problems which would require replacements sometimes.

- 'A normal joint is well lubricated and $\mu \approx 0.003$. The work expended is negligible.
- As we age, joint cartilage begins to wear out, efficiency of lubrication decreases and the joints may become seriously damaged.
-



- 'A normal joint is well lubricated and $\mu \simeq 0.003$. The work expended is negligible.
- As we age, joint cartilage begins to wear out, efficiency of lubrication decreases and the joints may become seriously damaged.
- Studies indicate that by the age of 70 about 2/3 of the people have knee joint problems and 1/3 have hip problems.

Hip Replacemets



Name of material	Property/Grade	Young's Modulu E(GPa)	Fatigue Limit s_{end}(MPa)	Ultimate Tensile Strength s_{UTS}(MPa)	Yield Strength s_y(MPa)	Elongation (min.	Density (g/cm^3)	Hardness (Hv)	Poisson's ratio	Bending strengt (MPa)	Reference
Stainless steel	316	190	240–820	515	203	40	8.02	155	0.25	—	[30,31]
		193	260	619	310	35	8	275–340	0.3	—	[32,86]
	316L	190	260	860	685	12	8	225	0.25	—	[38,86]
		190	260	503	195	40	8	199	0.3	—	[38,86]
		190	260	603	294	35	8	199	0.3	—	[31,87]
Co-based alloys	Cast CoCrMo	280	208–950	660	448–517	10	7.8	298	0.3	—	[38]
	Wrought CoCrMo	210	207–310	858	448–648	30	9.15	239	0.3	—	[38]
		210	586	1500	1606	9	9.15	445	0.3	—	[30]
		232	600–896	1000	965–1000	12	8.3	280	0.3	—	[31]
	Wrought CoNiCrMo	210	207–310	794–1000	240–655	50	8.1	—	0.3	—	[50]
		232	689–793	1794	1585	8	9.2	—	0.3	—	[30,31]
	Wrought CoNiCrMoFe	210	586	1515–1794	1606	2–4	8.5	—	0.3	—	[38,50]
		232	689–793	1862–2273	1500	1.0–17	8.3	—	0.3	—	[50]
	Wrought CoNiCrMoWFe	210	207–310	600	448–517	50	8.3	—	0.3	—	[38,41]
		210	586	1172	1606	12	8.3	—	0.3	—	[38,50]
Ti and its alloy	Grade1	107	300	240	170	24	4.5	122	0.34	—	[19]
	Grade2	105	425	345	275	20	4.51	145	0.37	—	[50]
	Grade3	107	240	450	380	18	4.5	280	0.36	—	[36,50]
	Grade4	103	250	550	485	15	4.5	280	0.39	—	[19,50]
	Ti6Al4V	116	620	860	795	10	4.43	349	0.342	—	[51]
	Ti13Nb13Zr	64	—	1030	900	15	4.66	245	0.3	—	[36]

Femoral component	Socket component	Results
Co-Cr-Mo	Co-Cr-Mo	High loosening rate and restricted use; new developments show minimum wear rate
Co-Cr-Mo	UHMWPE	extensively in use; low wear
Alumina/zirconia	UHMWPE	Very low wear rate; zirconia more impact resistant
Alumina	Alumina	Minimum wear rate (components matched); pain; not in clinical use in the United States
Ti-6Al-4V	UHMWPE	Reports of high UHMWPE wear due to breakdown of titanium surface
Surface-coated Ti-6Al-4V	UHMWPE	superior wear resistance to abrasion; merely thin treated layer attained

Hydroxyapatite

$Ca_{10}(PO_4)_6OH$

Development and characterization of bioceramic coatings for medicall and dental applications

Hydroxyapatite (HA), which is a natural component of bone tissue, is already being marketed as a coating for the metal shafts of hip implants as well as dental screws and other endoprostheses with the expectation of improved bonding to bone through osseointegration. Coatings prepared by the more widely used and commercial method, plasma spraying technique suffer from poor adhesion or delamination from the substrate. The high temperatures also results in a number of unstable decomposition phases compared to the more crystalline phase. The main purpose of the present research was to prepare and characterize HA coatings using low temperature sol-gel method with the specific aims of improving adhesion on both the HA/metal and HA/bone interface which have been reported failure modes of implants.

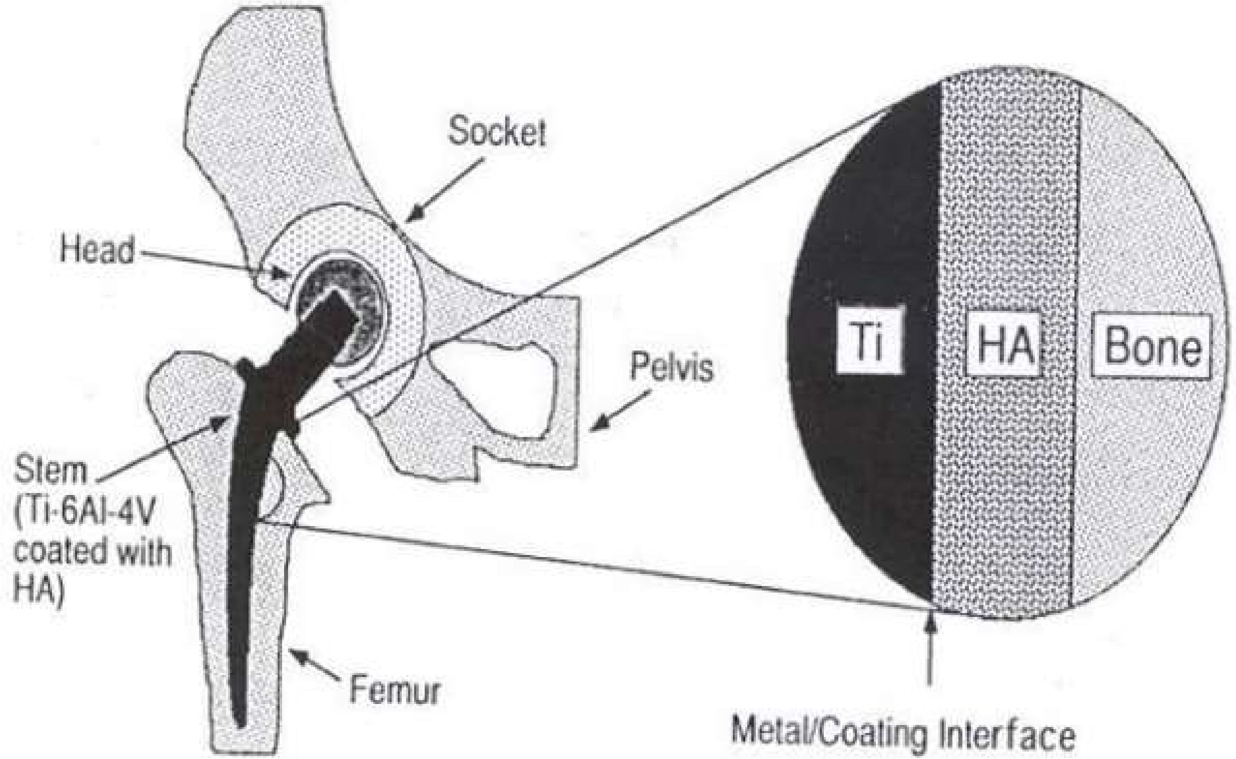
URI
http://hdl.handle.net/11394/2459

View/Open
Mudenda_MSC_2007.pdf (3.902Mb)

Collections
Magister Scientiae - MSc (Physics)

Date
2007

Author
Mudenda, Steven



;ure 1. 5: A sketch of HA coating as applied in a hip implant [43].