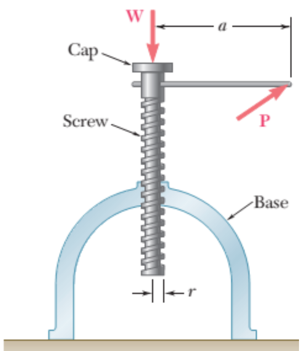
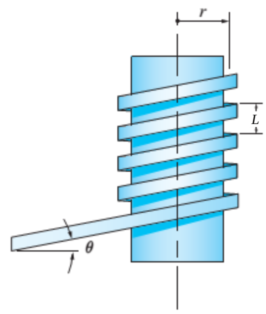
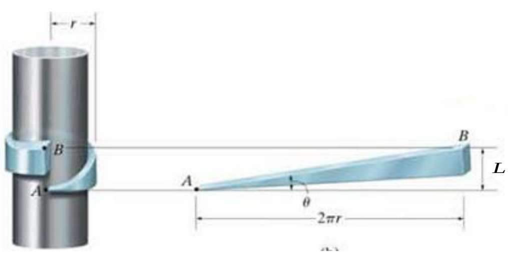
SIMPLE MACHINES
The Screw

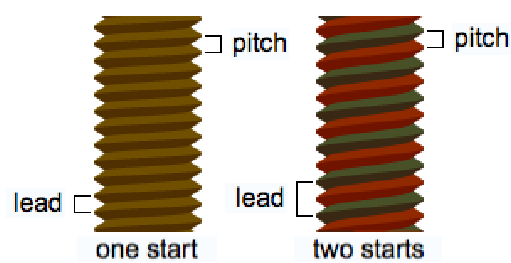
- Normally used as fasteners. But square-threaded screws are also often used for transmitting power.
- Can be considered as an inclined plane wrapped around a shaft.
- Often used in jacks, presses, vices, clamps, etc.



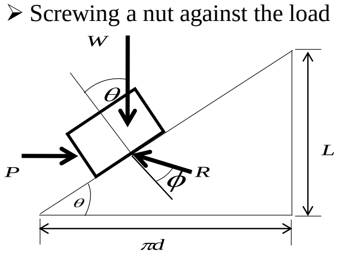


SIMPLE MACHINES
The Screw





- Screwing a nut against the load (moving the load up)



FBD

For equilibrium,

$$+\rightarrow \sum F_x = 0;\ P - R\sin(\phi+\theta) = 0 \qquad ---(1)$$

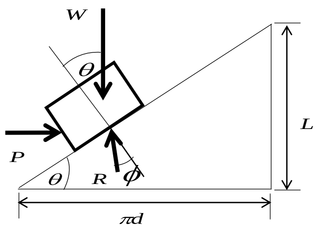
$$+\uparrow \sum F_y = 0;\ -W + R\cos(\phi+\theta) = 0 \qquad ---(2)$$

Eliminating R and simplifying, we obtain

$$P = W\tan(\phi+\theta)$$

SIMPLE MACHINES
The Screw

- For a load to move down on a screw that is NOT SELF-LOCKING,



FBD

For equilibrium,

$$+\rightarrow \sum F_x = 0; P + R\sin(\theta - \phi) = 0 \quad \text{---}(1)$$

$$+\uparrow \sum F_y = 0; -W + R\cos(\theta - \phi) = 0 \quad \text{---}(2)$$

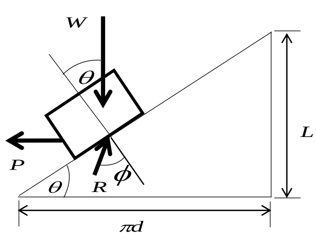
Eliminating R and simplifying, we obtain

$$P = W\tan(\theta - \phi)$$

- Load will move down when P = 0 N or if the P being applied is insufficient to maintain equilibrium or move the load upwards.

SIMPLE MACHINES
The Screw

- For a load to move down on a self locking screw,



FBD

For equilibrium,

$$+\rightarrow \sum F_x = 0; -P + R\sin(\phi - \theta) = 0 \quad \text{---}(1)$$

$$+\uparrow \sum F_y = 0; -W + R\cos(\phi - \theta) = 0 \quad \text{---}(2)$$

Eliminating R and simplifying, we obtain

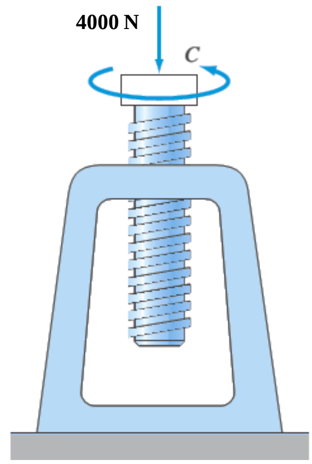
$$P = W\tan(\phi - \theta)$$

- Load won't move down until a force, P is applied as shown above. This is the situation in most practical scenarios, where screws **self-locking**. The loads self-locking screws support don't move down until a force is applied to move them down. Screws are also self locking when *Ø=Θ*.

SIMPLE MACHINES
The Screw

Example

The single-threaded screw of the floor jack has a pitch of 1.3 cm and a mean radius of 4.5 cm. The angle of static friction is 8.5°. Determine (a) the couple C that must be applied to the screw to start lifting a weight of 4000 N. (b) the couple required to start lowering the weight.



SIMPLE MACHINES
The Screw

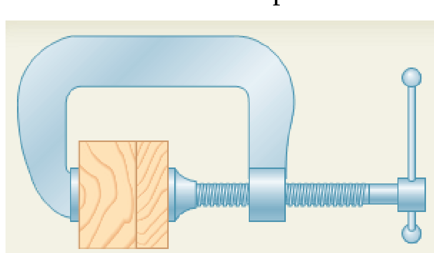
Example

A clamp is used to hold two pieces of wood together as shown. The clamp has a double square thread of mean diameter equal to 10 mm with a pitch of 2 mm. The coefficient of friction between threads is $\mu_s = 0.30$.

If a maximum couple of 40 Nm is applied in tightening the clamp, determine

(*a*) the force exerted on the pieces of wood,

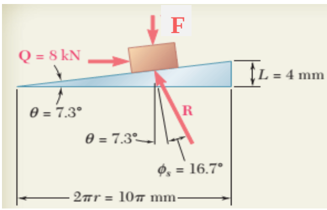
(*b*) the couple required to loosen the clamp.



SIMPLE MACHINES
The Screw

Example – Solution

Force exerted on wood in tightening the clamp



Summing forces,

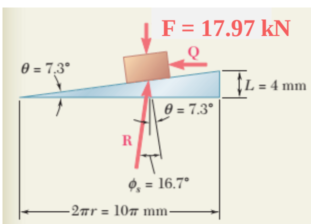
$$+\rightarrow \sum F_x = 0;\ 8\text{ kN} - R\sin\left(16.7^o + 7.3^o\right) = 0 \qquad ---(1)$$

$$+\uparrow \sum F_y = 0;\ -F + R\cos\left(16.7^o + 7.3^o\right) = 0 \qquad ---(2)$$

Solving simultaneously,

$F = 17.96$ kN

To loosen the clamp,



Summing forces,

$$+\rightarrow \sum F_x = 0;\ Q - R\sin 9.4^o = 0 \qquad ---(1)$$

$$+\uparrow \sum F_y = 0;\ -17.97\text{ kN} + R\cos 9.4^o = 0 \qquad ---(2)$$

Solving simultaneously,

$Q = 2.97$ kN

$$\text{Couple Required} = Q \times r = 2.97\text{ kN} \times 0.005\text{ m} = 14.85\text{ Nm}$$