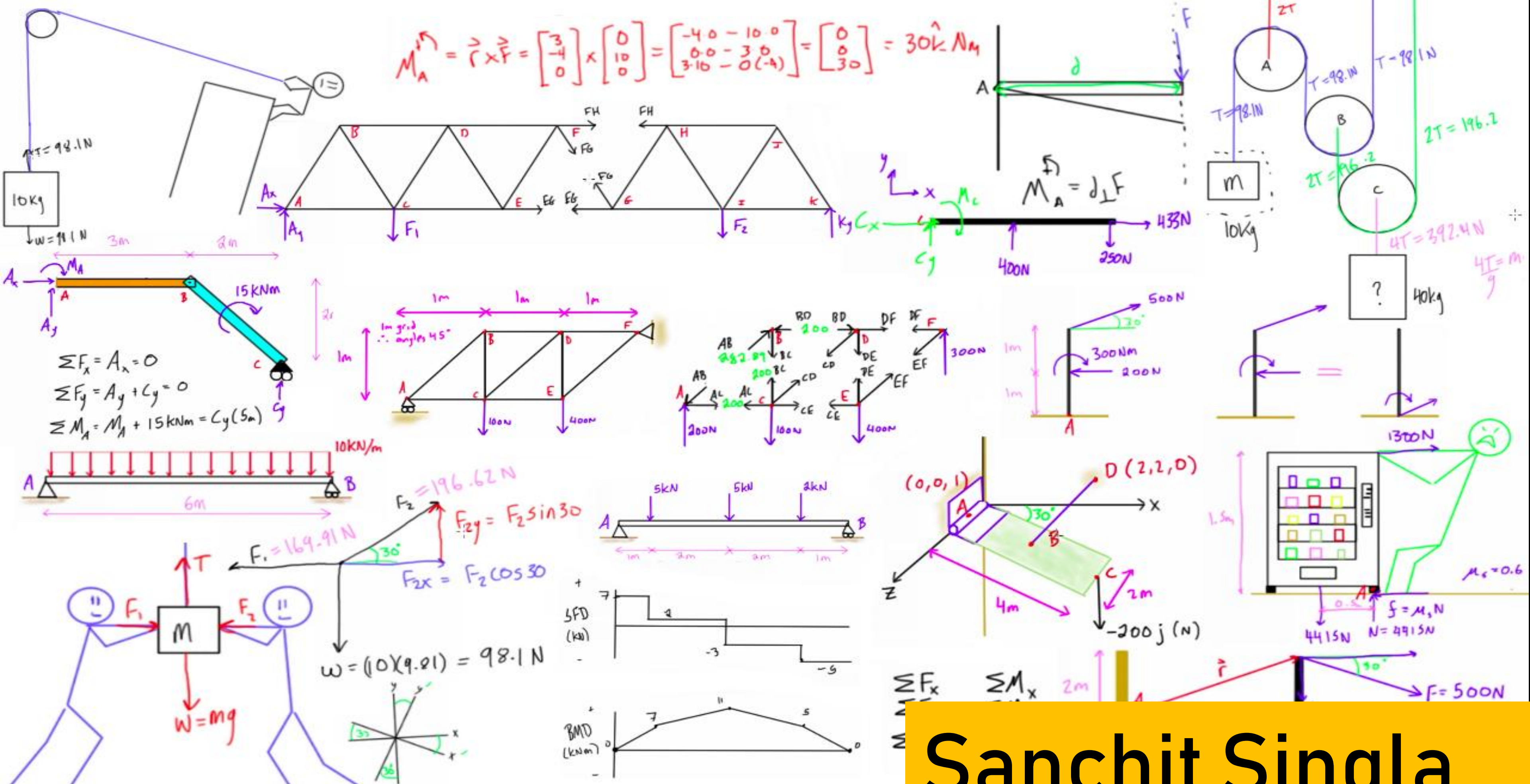

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MEC107

Basic Engineering Mechanics

Learning Outcomes

After this lecture, you will be able to

- ✓ learn Types of Friction.
- ✓ understand Laws of Friction.
- ✓ know about Angles of Friction
- ✓ understand about Coefficient of Friction

Introduction

Surfaces in contact were either *frictionless* (surfaces could move freely with respect to each other) or *rough* (tangential forces prevent relative motion between surfaces).

Actually, no perfectly frictionless surface exists. For two surfaces in contact, tangential forces, called friction forces, will develop if one attempts to move one relative to the other.

Friction: It is a tangential force between two surfaces ,when they are in contact .

There are two types of friction: dry or Coulomb friction and fluid friction. Fluid friction applies to lubricated mechanisms. The present discussion is limited to dry friction between non lubricated surfaces.

Types of Friction

1. Fluid friction: It is friction develops between layers of fluid moving at different velocities . Fluid friction develops between different layers of fluid moving at different velocities. fluid friction is of great importance in problems involving the flow of fluids through pipes & orifices or dealing with bodies immersed in moving mechanisms.

2. Dry friction: It resists relative lateral motion of two solid surface in contact. Dry friction is subdivided into static friction between non-moving surfaces, and kinetic friction between moving surfaces. Its engineering applications in journal bearing, rolling resistance & belt friction.

Laws of Friction

Law 1

When two bodies are in contact the direction of the forces of Friction on one of them at it's point of contact, is opposite to the direction in which the point of contact tends to move relative to the other.

Laws of Friction

Law 2

If the bodies are in equilibrium, the force of Friction is just sufficient to prevent motion and may therefore be determined by applying the conditions of equilibrium of all the forces acting on the body.

The amount of Friction that can be exerted between two surfaces is limited and if the forces acting on the body are made sufficiently great, motion will occur. Hence, we define limiting friction as the friction which is exerted when equilibrium is on the point of being broken by one body sliding on another. The magnitude of limiting friction is given by the following three laws.
of moving.

Laws of Friction

Law 3

The ratio of the limiting friction to the Normal reaction between two surfaces depends on the substances of which the surfaces are composed, and not on the magnitude of the Normal reaction. This ratio is usually denoted by μ .Thus if the Normal reaction is R, the limiting friction is μ R. For given materials polished to the same standard μ is found to be constant and independent of R. μ is called *The Coefficient of friction*

Laws of Friction

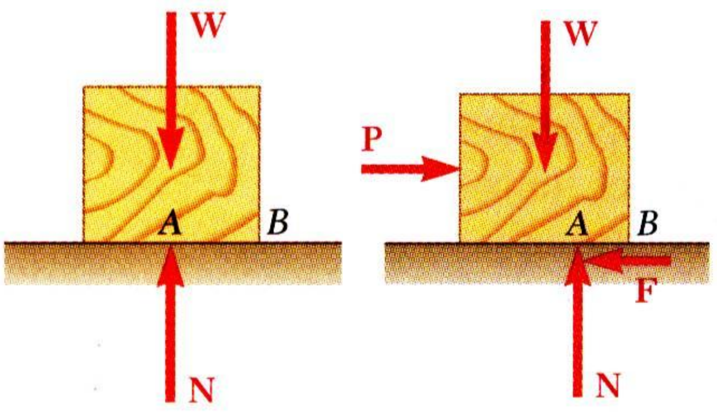
Law 4

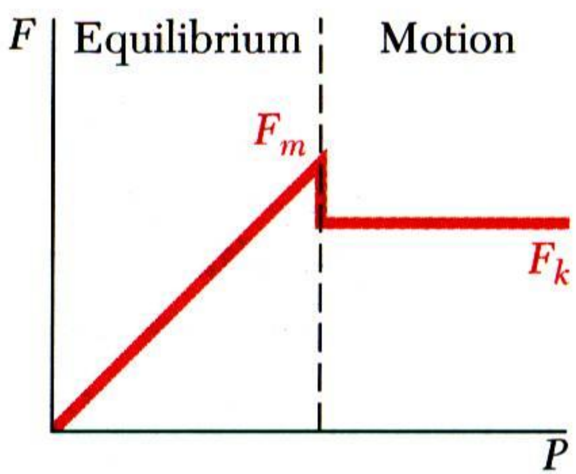
The amount of limiting friction is independent of the area of contact between the two surfaces and the shape of the surfaces, provided that the Normal reaction is unaltered.

Law 5

When motion takes place, the direction of friction is opposite to the direction of relative motion and is independent of velocity. The magnitude of the force of friction is in a constant ratio to the Normal reaction, but this ratio may be slightly less than when the body is just on the point of moving.

The Laws of Dry Friction: Coefficients Of Friction





- Block of weight *W* placed on horizontal surface. Forces acting on block are its weight and reaction of surface *N*.
- Small horizontal force P applied to block. For block to remain stationary, in equilibrium, a horizontal component F of the surface reaction is required. F is a static-friction force.
- As P increases, the static-friction force F increases as well until it reaches a maximum value Fm.

$$F_m = \mu_s N$$

- Further increase in P causes the block to begin to move as F drops to a smaller kinetic-friction force Fk.

$$F_k = \mu_k N$$

The Laws of Dry Friction: Coefficients Of Friction

Table 8.1. Approximate Values of Coefficient of Static Friction for Dry Surfaces

Metal on metal	0.15–0.60
Metal on wood	0.20–0.60
Metal on stone	0.30–0.70
Metal on leather	0.30–0.60
Wood on wood	0.25–0.50
Wood on leather	0.25–0.50
Stone on stone	0.40–0.70
Earth on earth	0.20–1.00
Rubber on concrete	0.60–0.90

- Maximum static-friction force:

$$F_m = \mu_s N$$

- Kinetic-friction force:

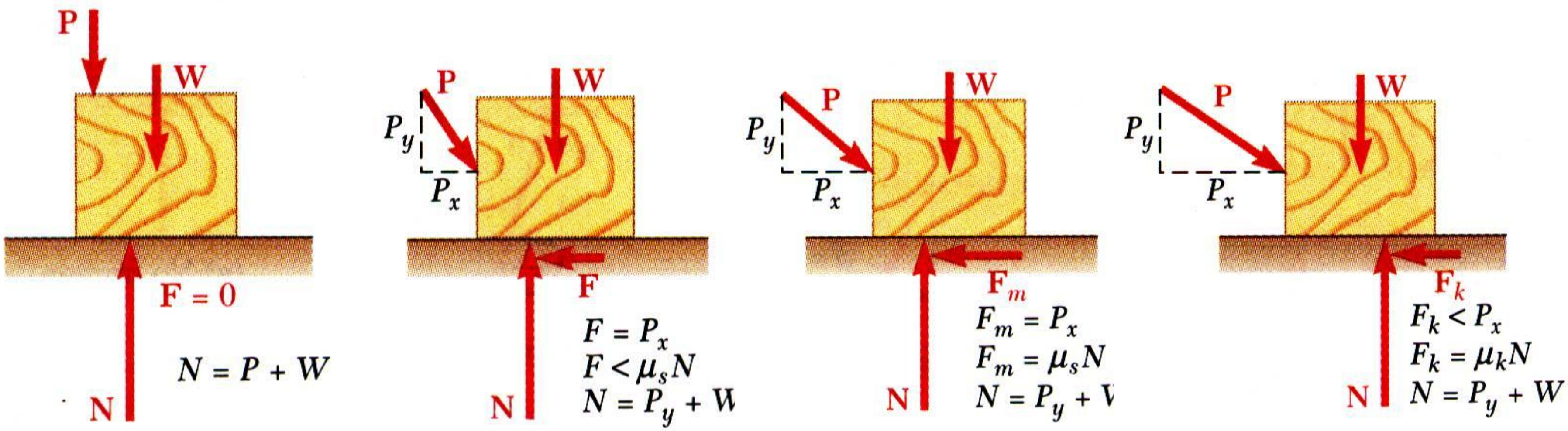
$$F_k = \mu_k N$$

$$\mu_k \cong 0.75\mu_s$$

- Maximum static-friction force and kinetic-friction force are:
- proportional to normal force
- dependent on type and condition of contact surfaces
- independent of contact area

The Laws of Dry Friction: Coefficients Of Friction

- Four situations can occur when a rigid body is in contact with a horizontal surface:

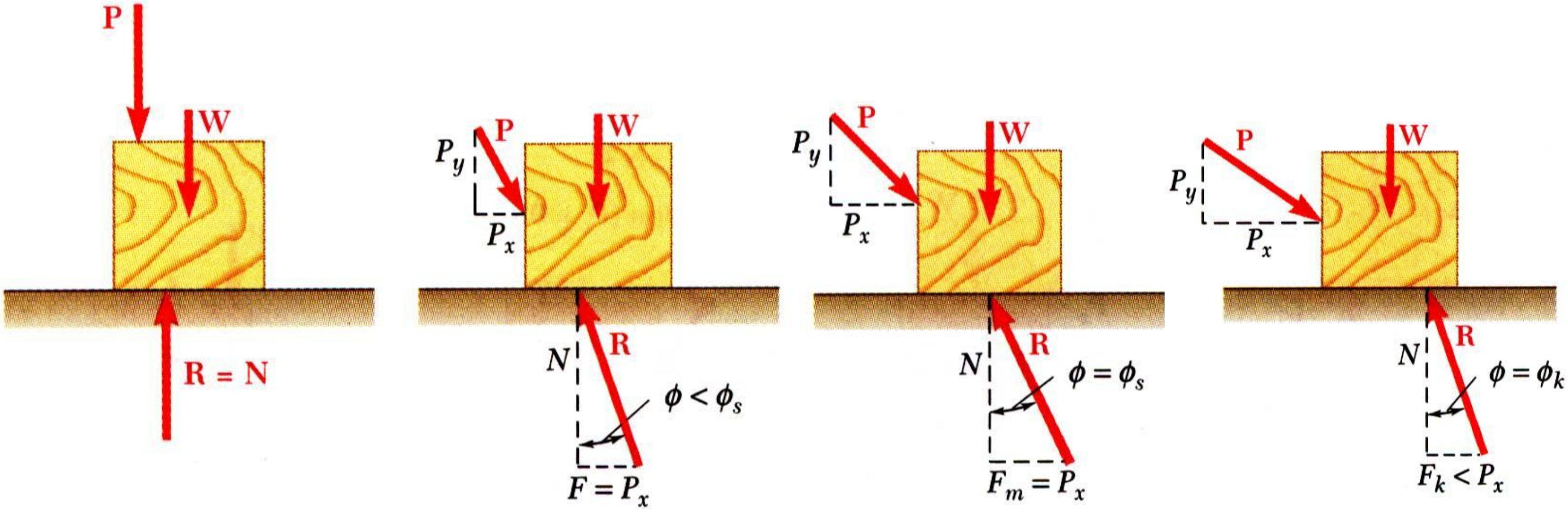


- No friction, ($P_x = 0$)
- No motion, (Px < Fm)
- Motion impending, (Px = Fm)
- Motion, (Px > Fm)

- Applied force is not enough to cause the motion
- Body is just about to slide
- Body is sliding

Angle of Friction

- It is sometimes convenient to replace normal force N and friction force F by their resultant $\boldsymbol{R}$:



- No friction
- No motion
- Motion impending
- Motion

$$\tan\phi_s = \frac{F_m}{N} = \frac{\mu_s N}{N}$$

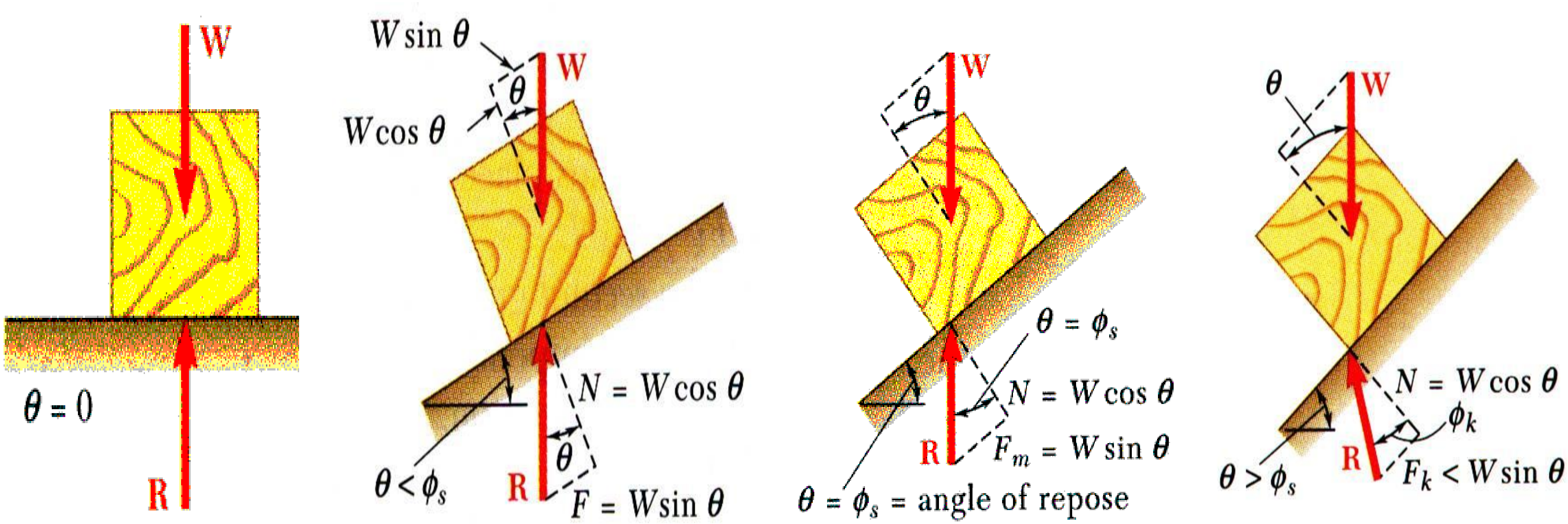
$$\tan\phi_s = \mu_s$$

$$\tan\phi_k = \frac{F_k}{N} = \frac{\mu_k N}{N}$$

$$\tan\phi_k = \mu_k$$

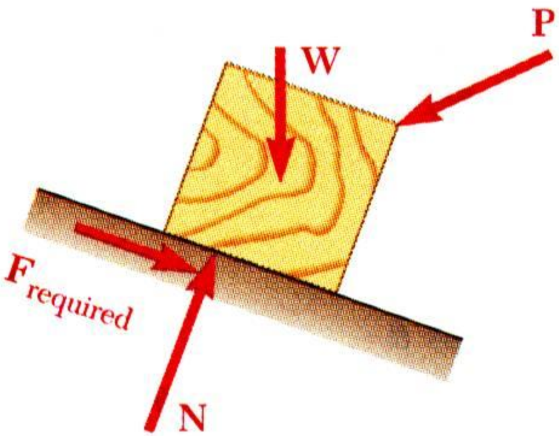
Angle of Friction

- Consider block of weight *W* resting on board with variable inclination angle *q*.

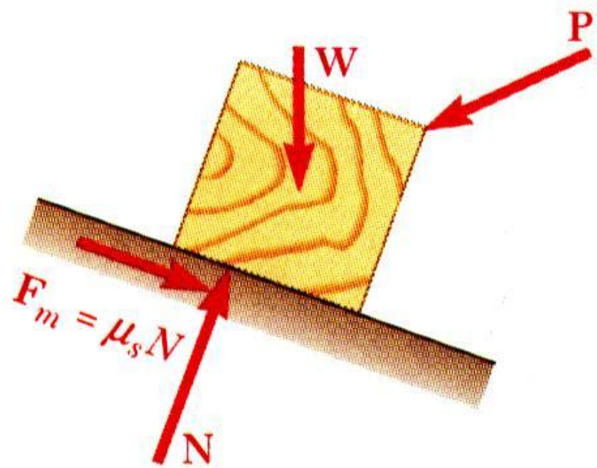


- No friction
- No motion
- Motion impending
- Motion

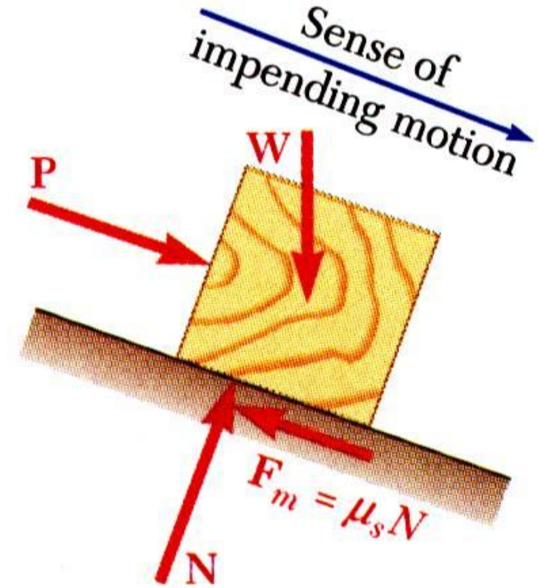
Problems Involving Dry Friction



- All applied forces known
- Coefficient of static friction is known
- Determine whether body will remain at rest or slide

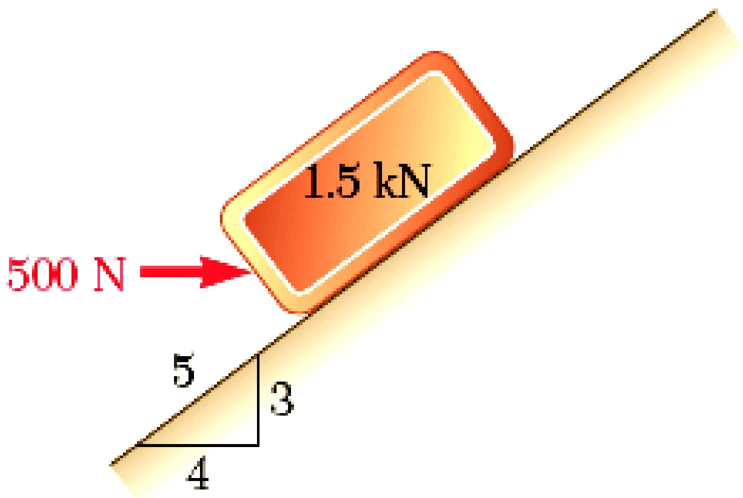


- All applied forces known
- Motion is impending
- Determine value of coefficient of static friction.



- Coefficient of static friction is known
- Motion is impending
- Determine magnitude or direction of one of the applied forces

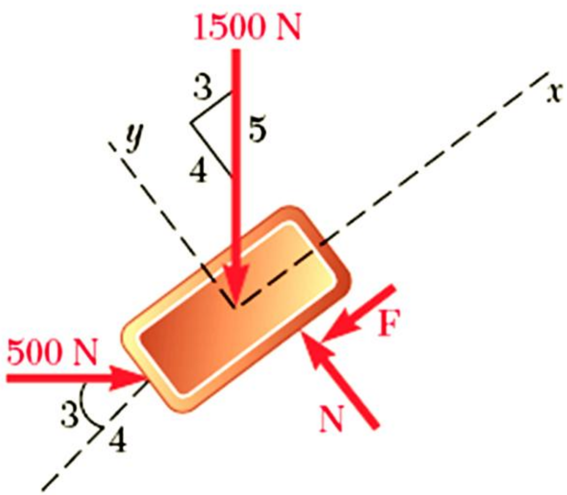
Numerical



- A 500-N force acts as shown on a 1.5 kN block placed on an inclined plane. The coefficients of friction between the block and plane are ms = 0.25 and mk = 0.20. Determine whether the block is in equilibrium and find the value of the friction force.

- SOLUTION:
- Determine values of friction force and normal reaction force from plane required to maintain equilibrium.
- Calculate maximum friction force and compare with friction force required for equilibrium. If it is greater, block will not slide.
- If maximum friction force is less than friction force required for equilibrium, block will slide. Calculate kinetic-friction force.

Numerical



- SOLUTION:
- Determine values of friction force and normal reaction force from plane required to maintain equilibrium.

$$\sum F_x = 0: \qquad \tfrac{4}{5}(500\,\mathrm{N}) - \tfrac{3}{5}(1500\,\mathrm{N}) - F = 0$$

$$F = -500\,\mathrm{N}$$

$$\sum F_y = 0: \qquad N - \tfrac{4}{5}(500\,\mathrm{N}) - \tfrac{3}{5}(500\,\mathrm{N}) = 0$$

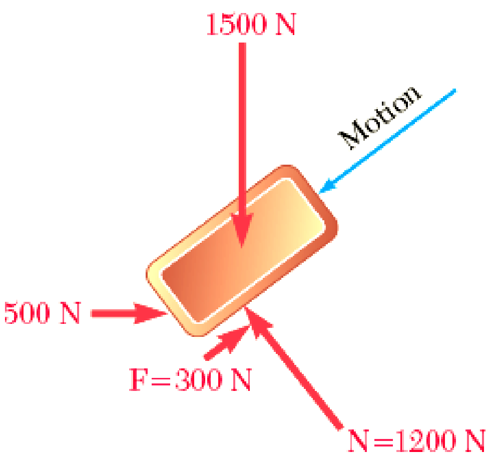
$$N = 1500\,\mathrm{N}$$

- Calculate maximum friction force and compare with friction force required for equilibrium. If it is greater, block will not slide.

$$F_m = \mu_s N \qquad F_m = 0.25(1500\,\mathrm{N}) = 375\,\mathrm{N}$$

The block will slide down the plane.

Numerical

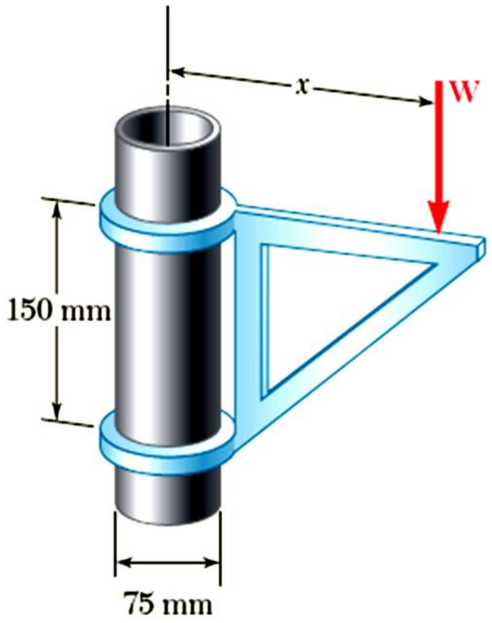


- If maximum friction force is less than friction force required for equilibrium, block will slide. Calculate kinetic-friction force.

$$F_{actual} = F_k = \mu_k N$$
$$= 0.20(1500\,\text{N})$$

$$\boxed{F_{actual} = 300\,\text{N}}$$

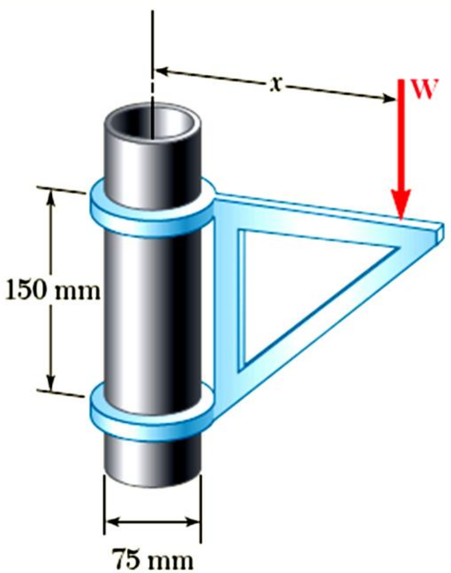
Numerical

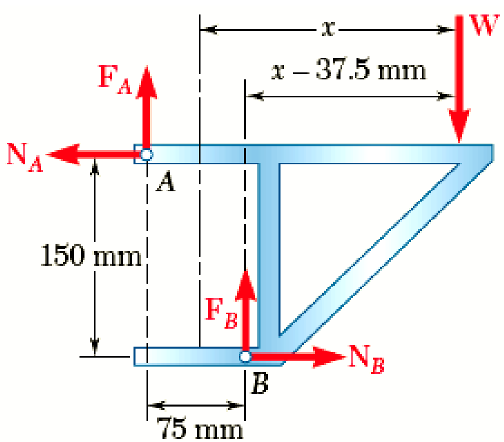


- The moveable bracket shown may be placed at any height on the 75 mm. diameter pipe. If the coefficient of friction between the pipe and bracket is 0.25, determine the minimum distance x at which the load can be supported. Neglect the weight of the bracket.

- SOLUTION:
- When W is placed at minimum x, the bracket is about to slip and friction forces in upper and lower collars are at maximum value.
- Apply conditions for static equilibrium to find minimum x.

Numerical





- SOLUTION:
- When W is placed at minimum x, the bracket is about to slip and friction forces in upper and lower collars are at maximum value.

$$F_A = \mu_s N_A = 0.25 N_A$$
$$F_B = \mu_s N_B = 0.25 N_B$$

- Apply conditions for static equilibrium to find minimum *x*.

$$\sum F_x = 0: \quad N_B - N_A = 0 \qquad N_B = N_A$$

$$\sum F_y = 0: \quad F_A + F_B - W = 0$$
$$0.25 N_A + 0.25 N_B - W = 0 \qquad N_A = N_B = 2W$$
$$0.5 N_A = W$$

$$\sum M_B = 0: \quad N_A(150\,\text{mm}) - F_A(75\,\text{mm}) - W(x - 35.5\,\text{mm}) = 0$$
$$150 N_A - 75(0.25 N_A) - Wx + 37.5W = 0$$
$$150(2W) - 18.75(2W) - Wx + 37.5W = 0$$
$$\boxed{x = 300\,\text{mm}}$$