K J SOMAIYA COLLEGE OF ENGINEERING, MUMBAI-77

(CONSTITUENT COLLEGE OF SOMAIYA VIDYAVIHAR UNIVERSITY)

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- **Kinetics of particle**

5.2	Work energy principle

Newton's laws of motion

- ❖ The first law states that an object either remains at rest or continues to move at a constant velocity, unless it is acted upon by an external force.
- ❖ The second law states that the rate of change of momentum of an object is directly proportional to the force applied.
  - ➢ or, for an object with constant mass, that the net force on an object is equal to the mass of that object multiplied by the acceleration.
- ❖ The third law states that when one object exerts a force on a second object, that second object exerts a force that is equal in magnitude and opposite in direction on the first object.

Newton's second law

- The second law states that the rate of change of momentum of a body over time is directly proportional to the force applied, and occurs in the same direction as the applied force.
- For objects and systems with constant mass, the second law can be re-stated in terms of an object's acceleration.

$$\mathbf{F} = \frac{\mathrm{d}(m\mathbf{v})}{\mathrm{d}t} = m\,\frac{\mathrm{d}\mathbf{v}}{\mathrm{d}t} = m\mathbf{a},$$

✓ where **F** is the net force applied, *m* is the mass of the body, and **a** is the body's acceleration.

✓ Thus, the net force applied to a body produces a proportional acceleration.

WORK

- Work provides a means of determining the motion of an object when the force applied to it is known as a function of position.
  - ❑ W_{net} is the work done by
  - ❑ F_{net} the net force acting on a body.

$$W_{net} = \int_{x_i}^{x_f} F_{net} dx$$

$$= \int_{x_i}^{x_f} madx = m\int_{x_i}^{x_f} \frac{dv}{dt} dx$$

$$= m\int_{v_i}^{v_f} \frac{dx}{dt} dv = m\int_{v_i}^{v_f} vdv$$

$$W_{net} = m\int_{v_i}^{v_f} vdv$$

$$= m\left[\frac{v^2}{2}\right]_{v_i}^{v_f} = \tfrac{1}{2} m(v_f^2 - v_i^2)$$

$$W_{net} = \tfrac{1}{2} mv_f^2 - \tfrac{1}{2} mv_i^2$$

Work-energy theorem

- **Statement**: It states that the work done by the resultant force F acting on a particle as it move from point 1 to point 2 along its trajectory is equal to the change in the kinetic energy (KE2 − KE1) of the particle during the given displacement.

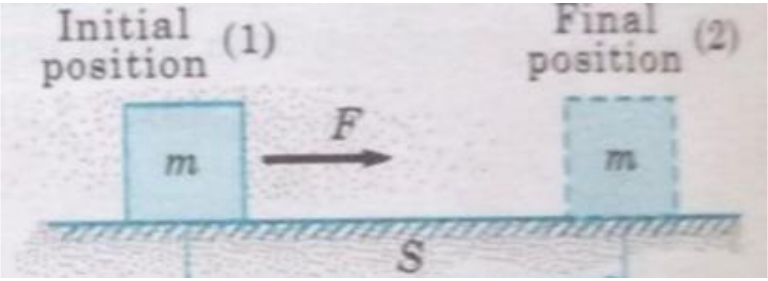
$$W_{net} = \frac{1}{2} m v_2^2 - \frac{1}{2} m v_1^2$$

$$W_{net} = KE_2 - KE_1 = \Delta KE$$

Work done by external force

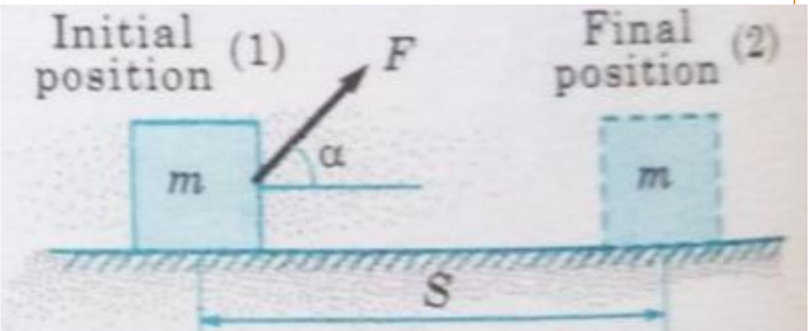
- Work done = Force x Displacement

  = F x S



- Work done = Force x Displacement

  = (F cosα) x S



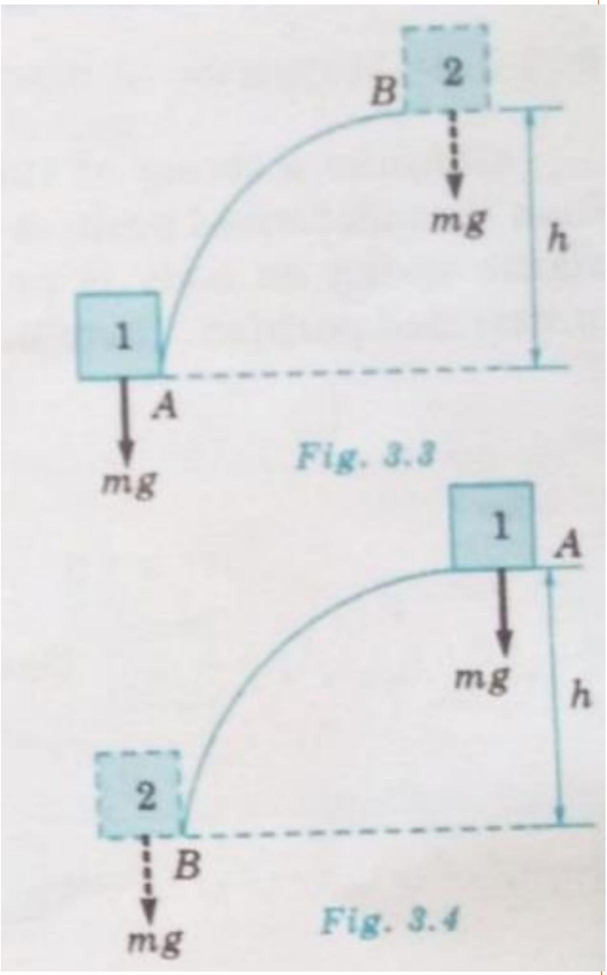
Work done by gravitational force

- Work done = Force x Displacement

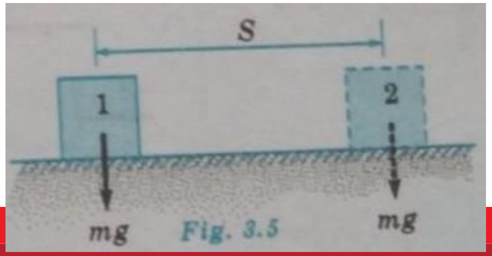
  = - mg x h (Negative work)

- Work done = Force x Displacement

  = mg x h (Positive work)



- Work done = 0

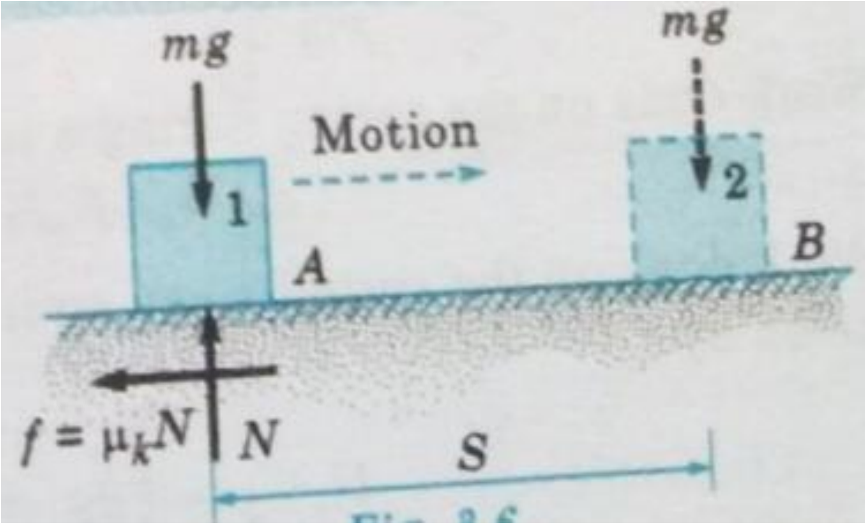


Work done by frictional force

- Work done = Force x Displacement

  $= -(\mu_k N) \times S$

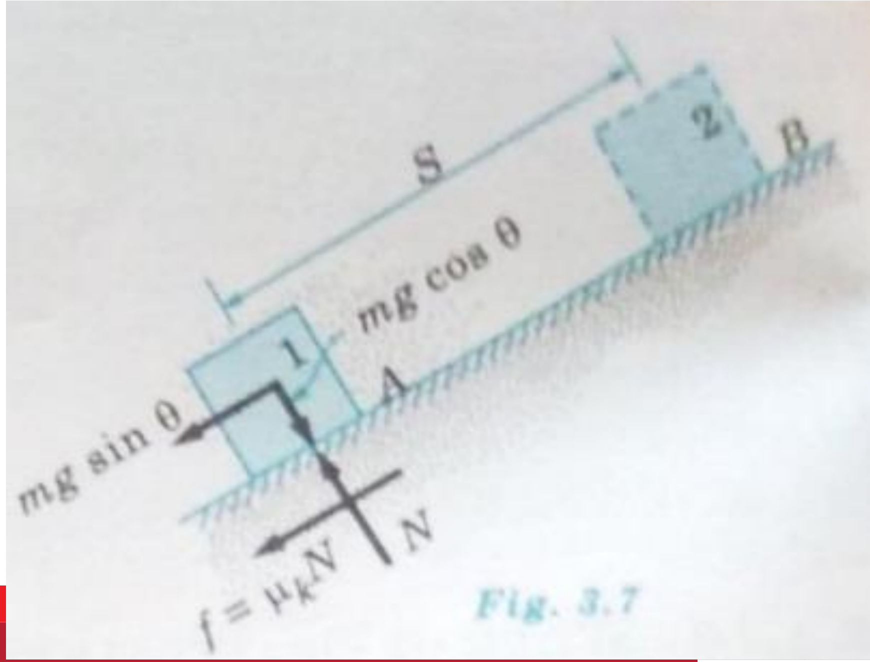
  $= -(\mu_k \times mg) \times S$



- Work done = Force x Displacement

  $= -(\mu_k N) \times S$

  $= -(\mu_k \times mg\cos\theta) \times S$



Work done by spring force

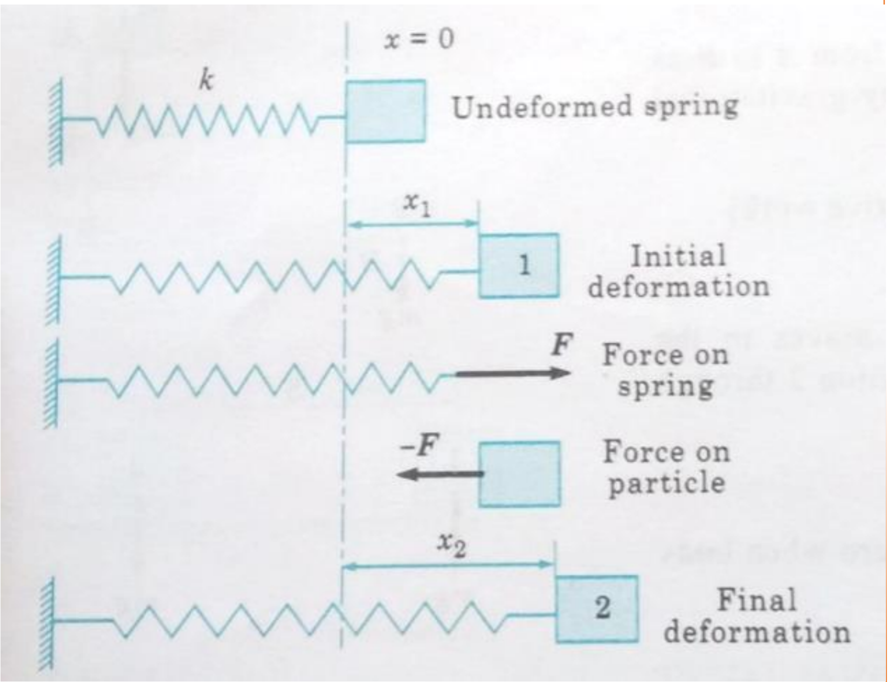
- Spring force = F = kx

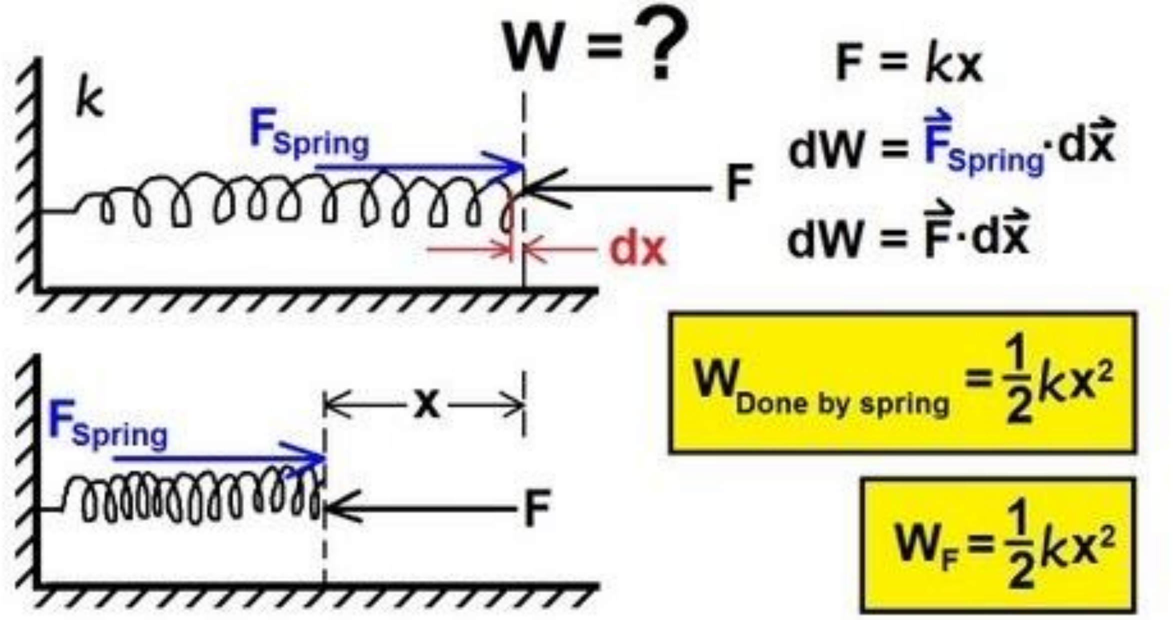
  Where, x = Deflection of spring

  k = spring stiffness

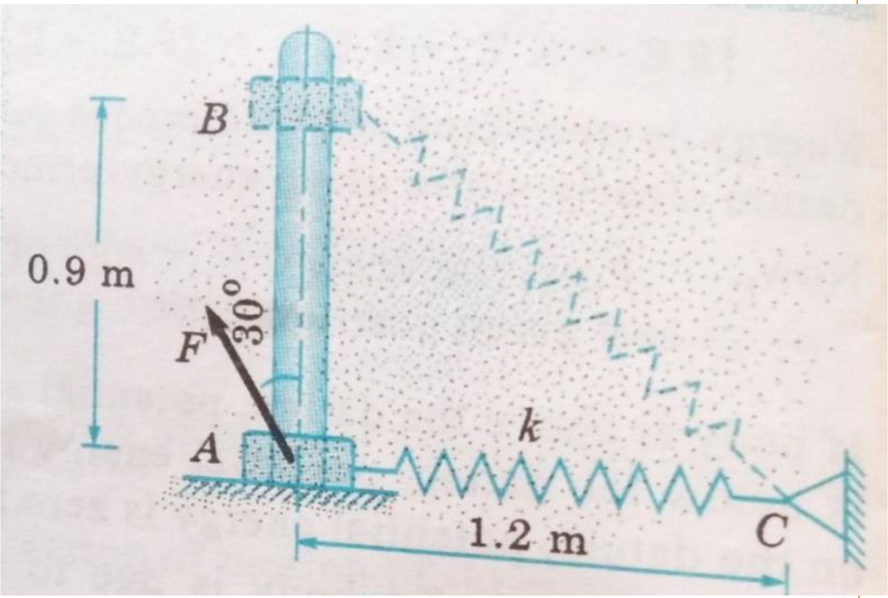
- Work done = Force x small displacement

  = ±F x dx

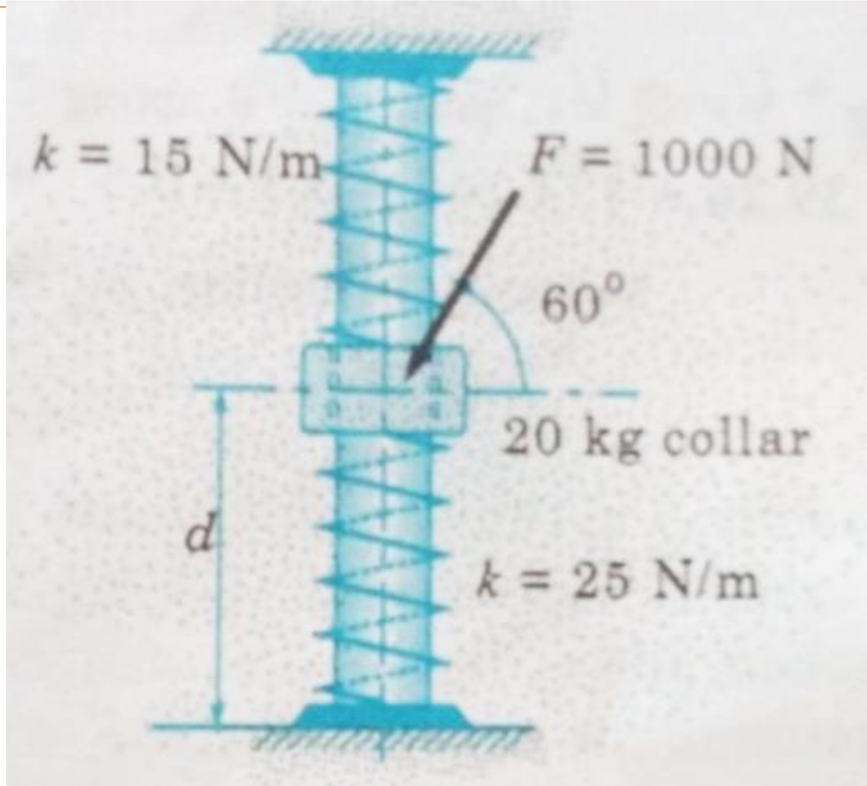




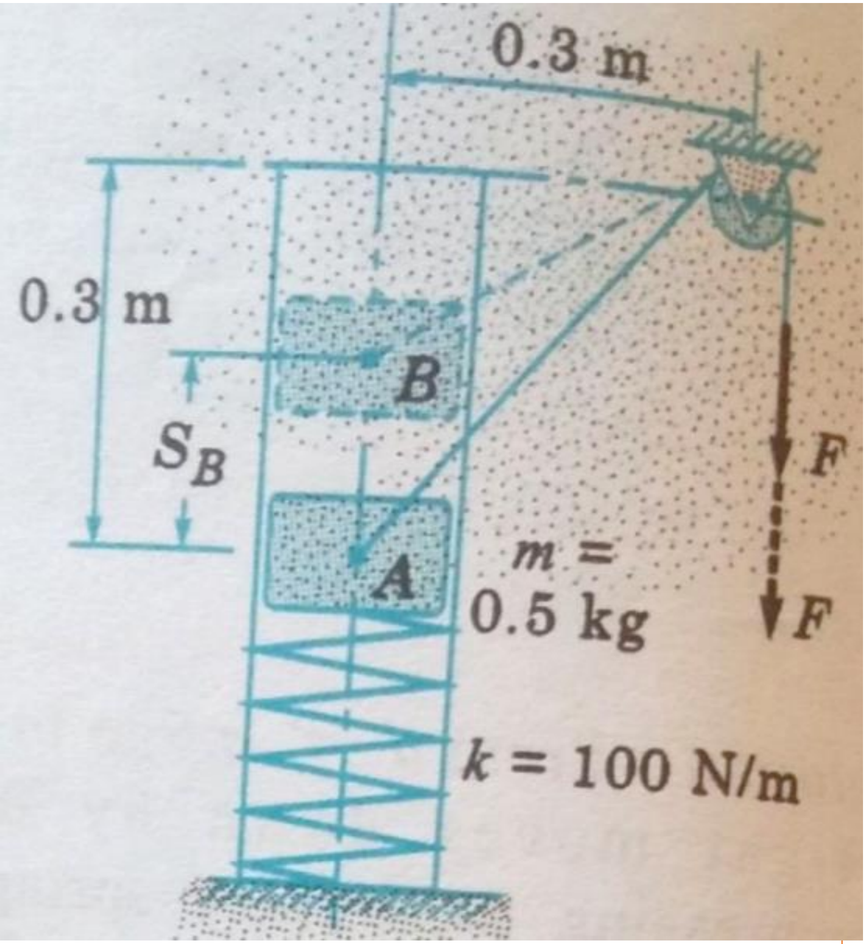
- **Problem No. 1:** Collar of mass 15 kg is at rest at A. It can freely slide in a vertical smooth rod AB. The collar is pulled by a constant force F = 800 N acting at an angle of 30° with the vertical as shown in figure. The unstretched length of spring is 1 m. Calculate the velocity of collar when it reaches B. Take spring constant k= 3000 N/m and AC is horizontal.



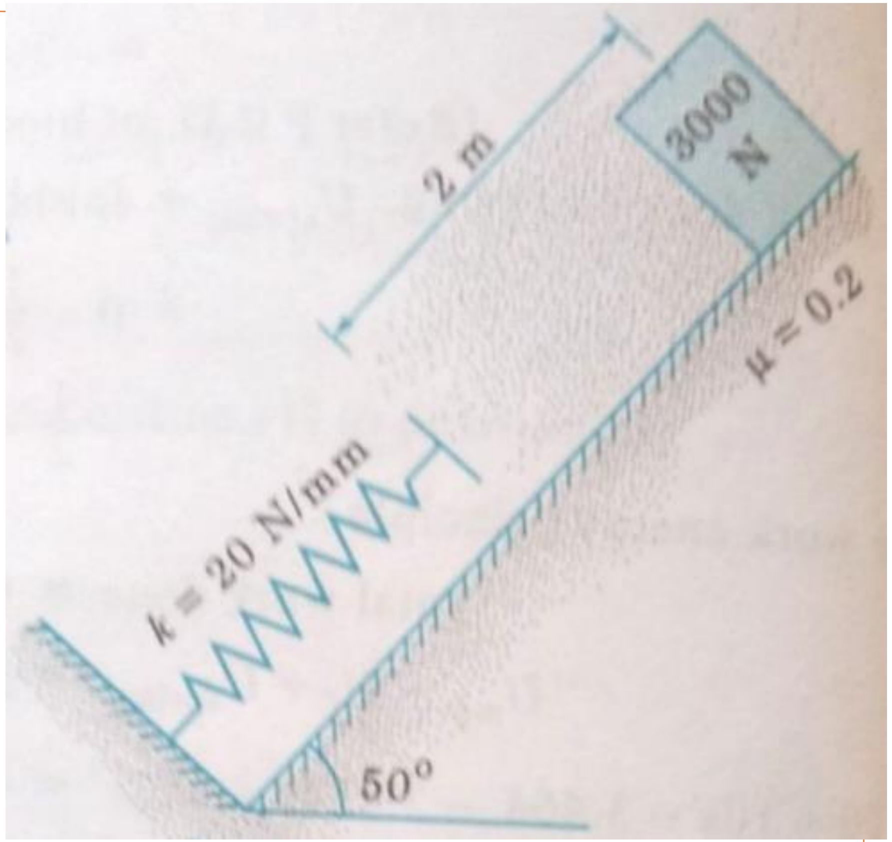
- **Problem No. 2:** Figure shows a collar of mass 20 kg which is supported on a smooth rod. The attached springs are undeformed when d = 0.5 m. Determine the speed of the collar after the applied force of 1000 N causes it to displace so that d = 0.3 m. The collar is at rest when d = 0.5 m.



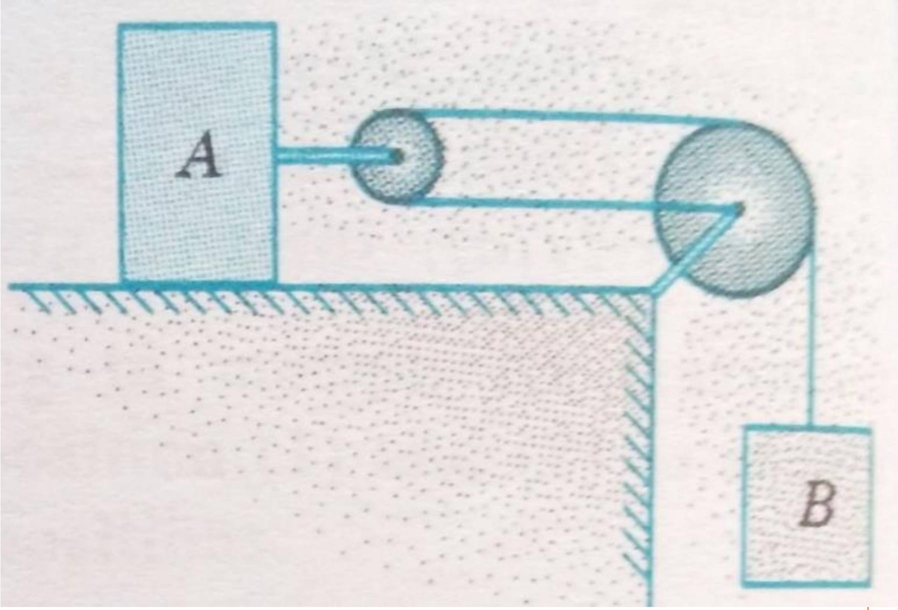
- **Problem No. 3:** The block of mass 0.5 kg moves within the smooth vertical slot. If it starts from rest, when the attached spring is in the unstretched position at A. Determine the constant force F which must be applied to the cord so that block attains a speed of 2.5 m/s when it reaches B, i.e. $S_B = 0.15$m. Neglect the mass of the cord and pulley.



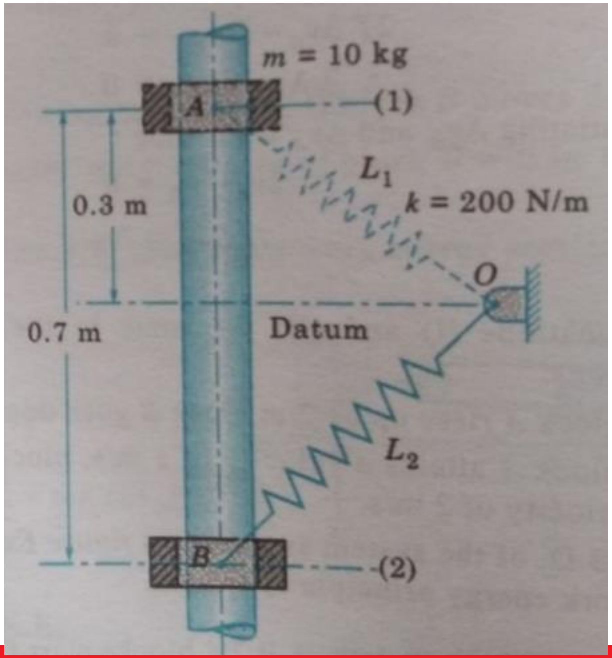
- **Problem No. 4:** A 3000 N block shown in figure slides down a 50° incline. It starts from rest. After moving 2 m it strikes a spring whose modulus is 20 N/mm. If the coefficient of friction between the block and incline is 0.2, determine the maximum deformation of the spring.

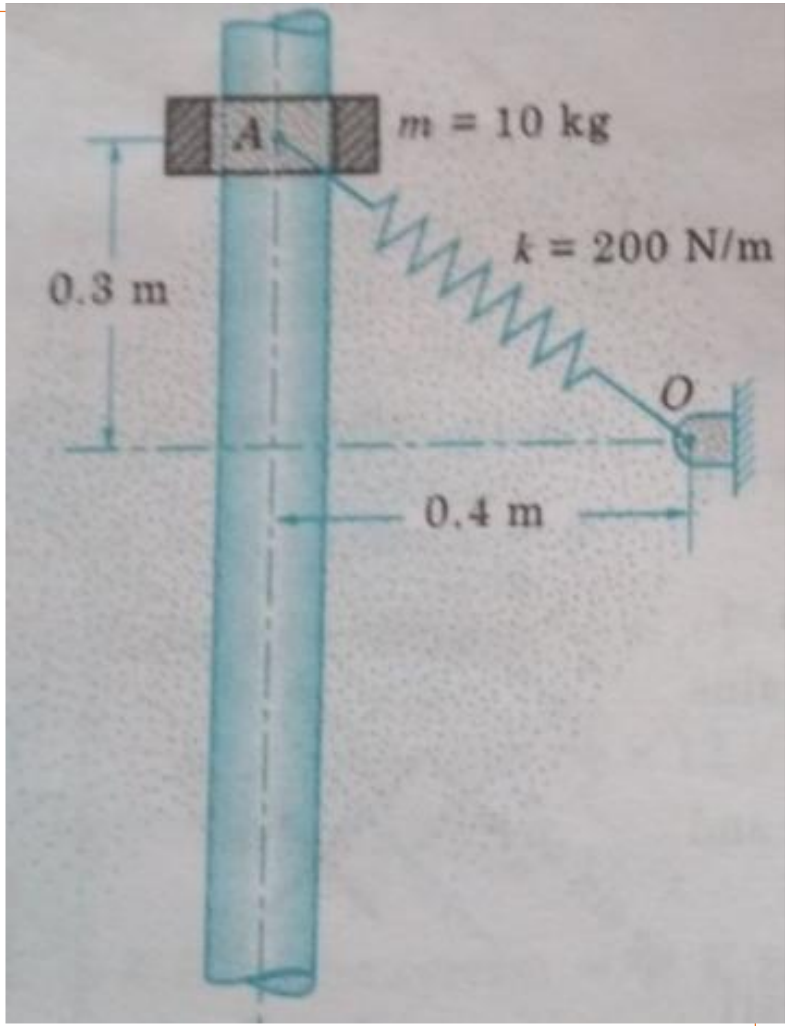


- **Problem No. 5:** The system shown in the figure is released from rest. Determine the velocity of each block when block B has descended 1.5 m. The mass of the blocks are m_A = 12 kg, m_B = 6 kg and coefficient of kinetic friction between block A and the horizontal surface is 0.20.

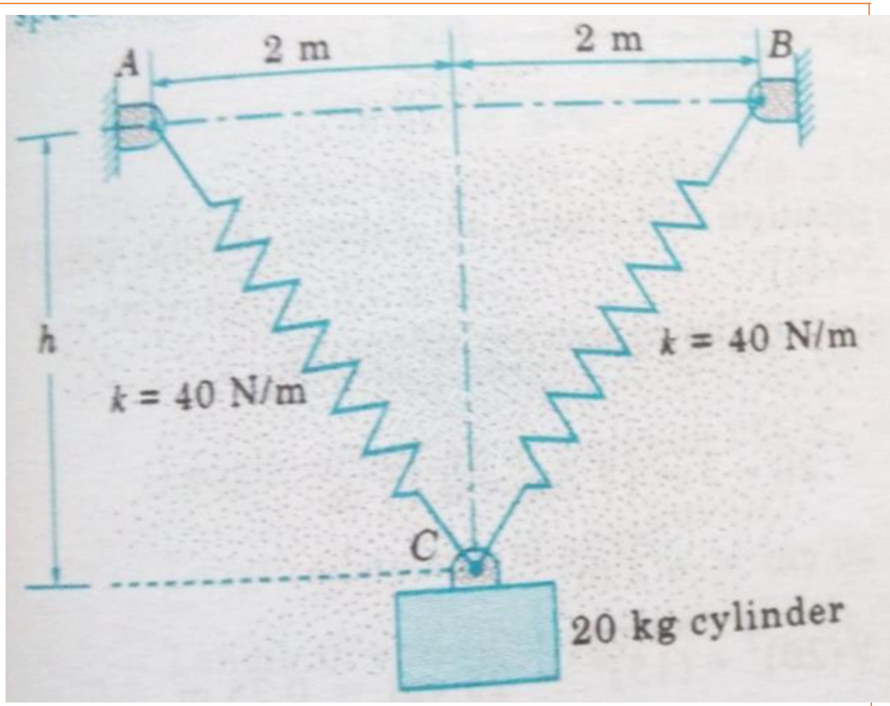


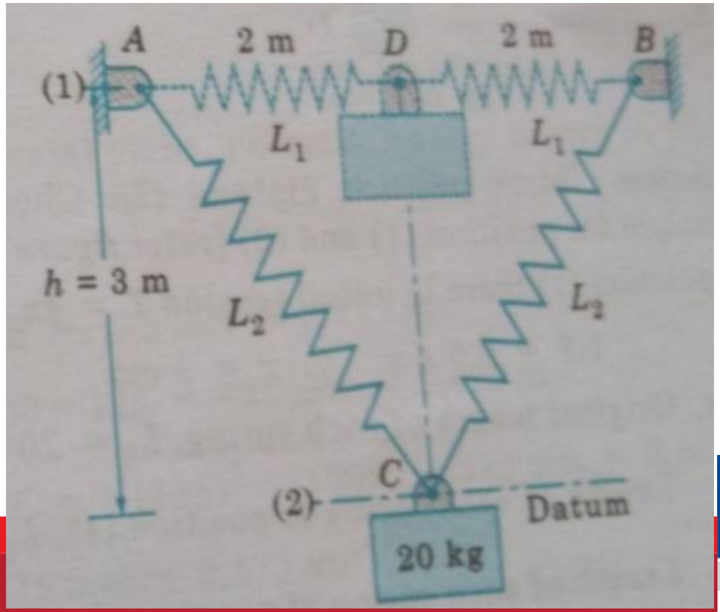
- **Problem No. 6:** A collar of mass 10 kg moves on a vertical guide as shown in the figure. Neglecting friction between the guide and the collar find the velocity of the collar after it has fallen 0.7 m starting rest from the position shown. The unstretched length of the spring is 0.2 m and its stiffness is 200 N/m.





- **Problem No. 7:** A cylinder has a mass 20 kg and is released from rest when h = 0. Determine the speed when h = 3 m. The springs each have an unstretched length of 2 m.





- **Problem No. 8:** Two springs each of stiffness 0.5 N/cm are connected to ball B having a mass of 5 kg. In the horizontal position, there is a tension of 1.5 N in each spring. If the ball is allowed to fall from rest, what will be its velocity after it has fallen through a height of 15 cm.