Course Code: ESC106A
Course Title: Construction Materials and Engineering Mechanics

Lecture No. 48:
Problems on Rope friction

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Lecture Intended Learning Outcomes

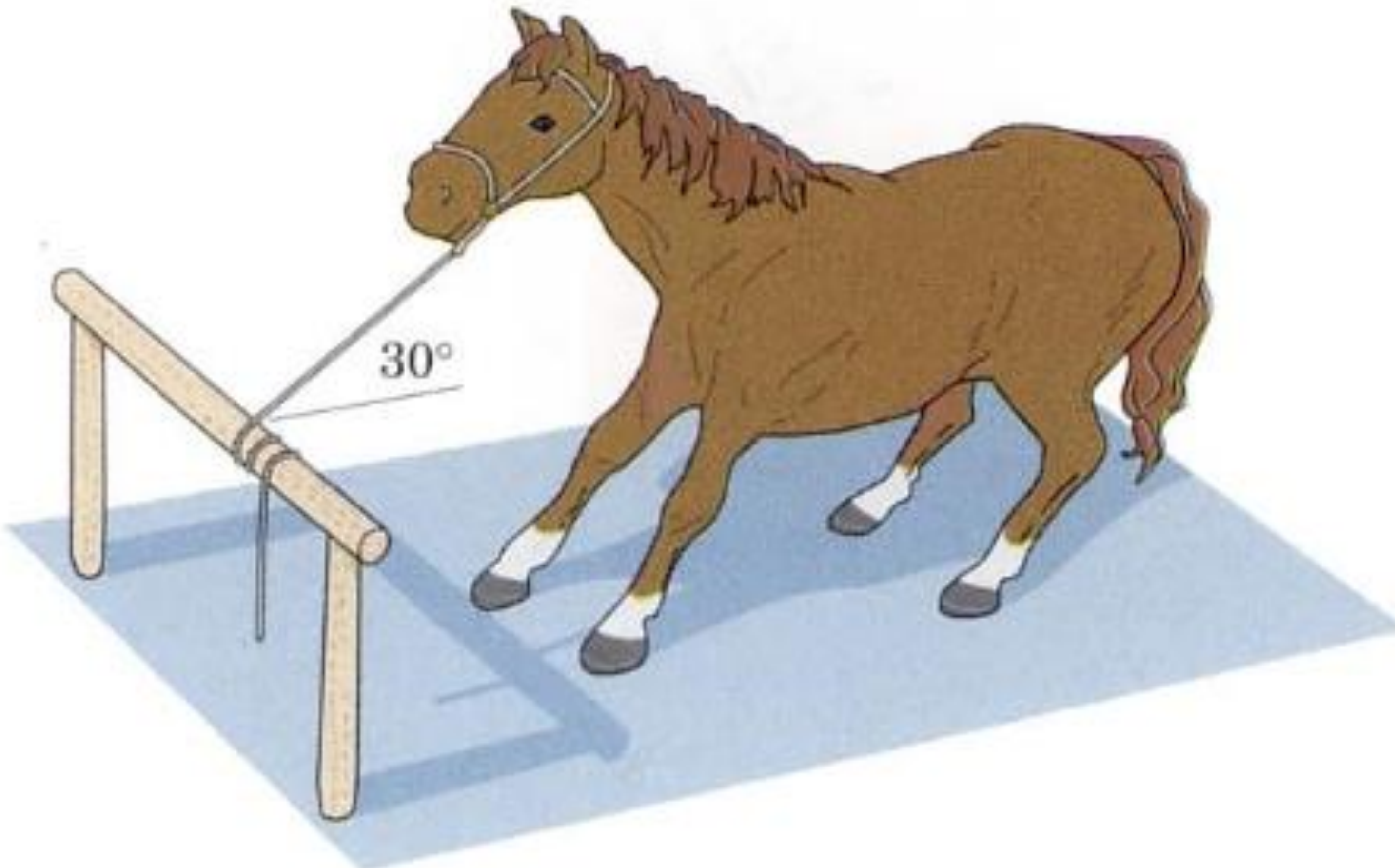
At the end of this lecture, students will be able to:

- Draw Free Body diagrams of pulley in the given problems
- Evaluate frictional forces or find tension in the string on either side of the pulley by assuming impending state

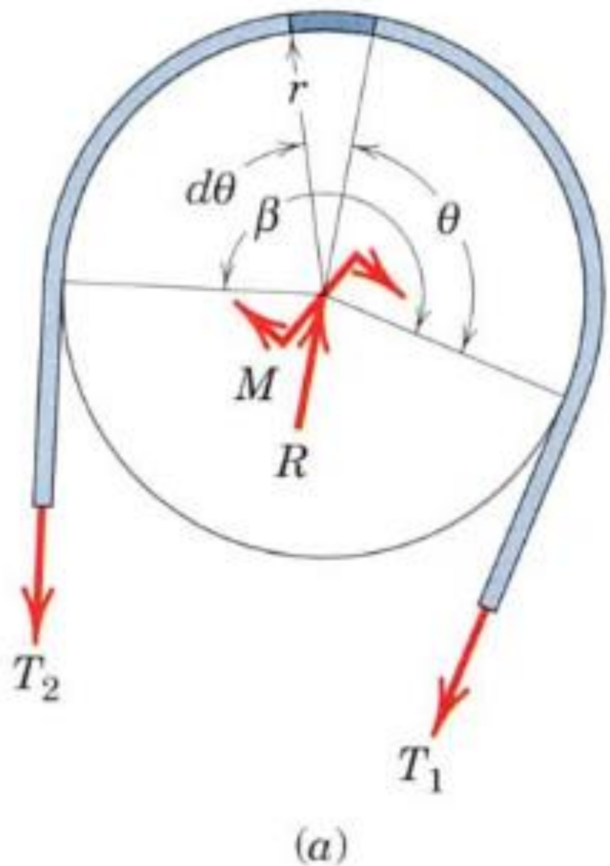
Contents

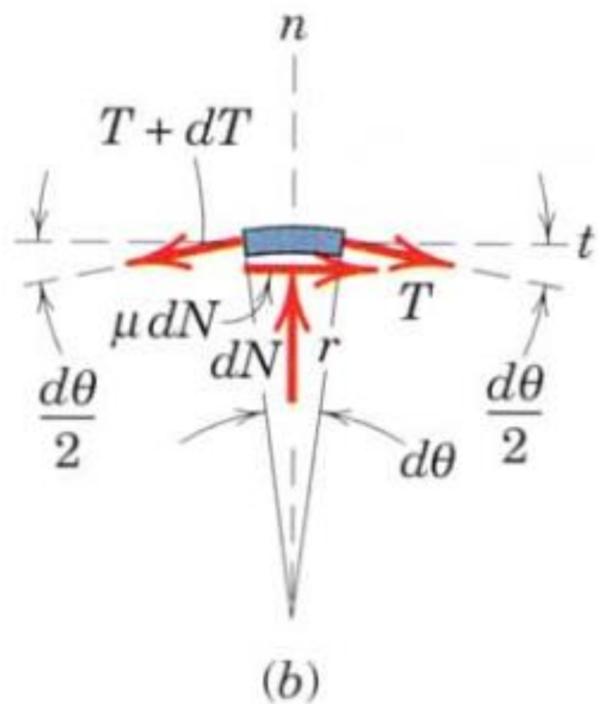
- Numerical problems on rope friction

Introduction



Rope Friction





Rope Friction

Equilibrium in the t-direction gives

$$T \cos \frac{d\theta}{2} + \mu \, dN = (T + dT) \cos \frac{d\theta}{2}$$

or

$$\mu \, dN = dT$$

since the cosine of a differential quantity is unity in the limit. Equilibrium in the n-direction requires that

$$dN = (T + dT) \sin \frac{d\theta}{2} + T \sin \frac{d\theta}{2}$$

or

$$dN = T \, d\theta$$

Rope Friction

Combining the two equilibrium relations gives

$$\frac{dT}{T} = \mu \, d\theta$$

Integrating between corresponding limits yields

$$\int_{T_1}^{T_2} \frac{dT}{T} = \int_0^{\beta} \mu \, d\theta$$

or

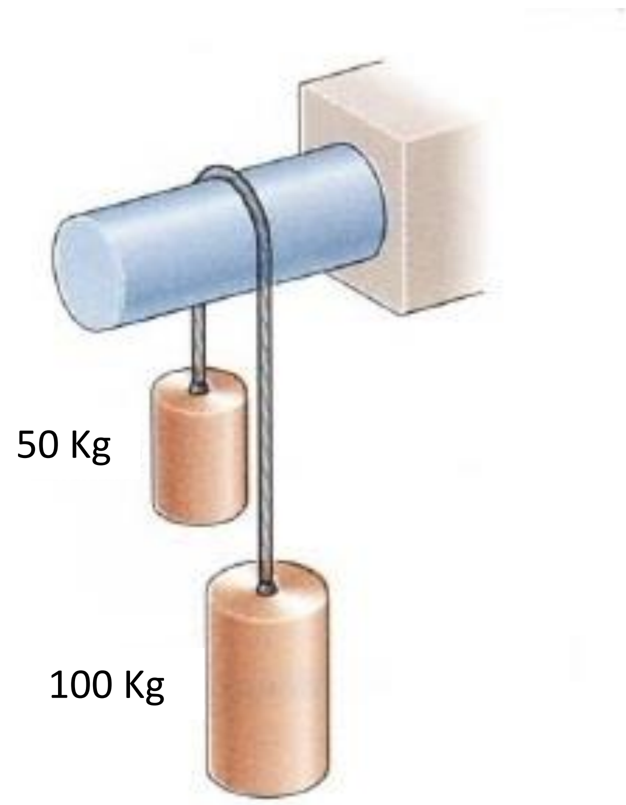
$$\ln \frac{T_2}{T_1} = \mu\beta$$

where the ln (T_2/T_1) is a natural logarithm (base e). Solving for T_2 gives

$$T_2 = T_1 e^{\mu\beta}$$

Rope Friction: Problem 1

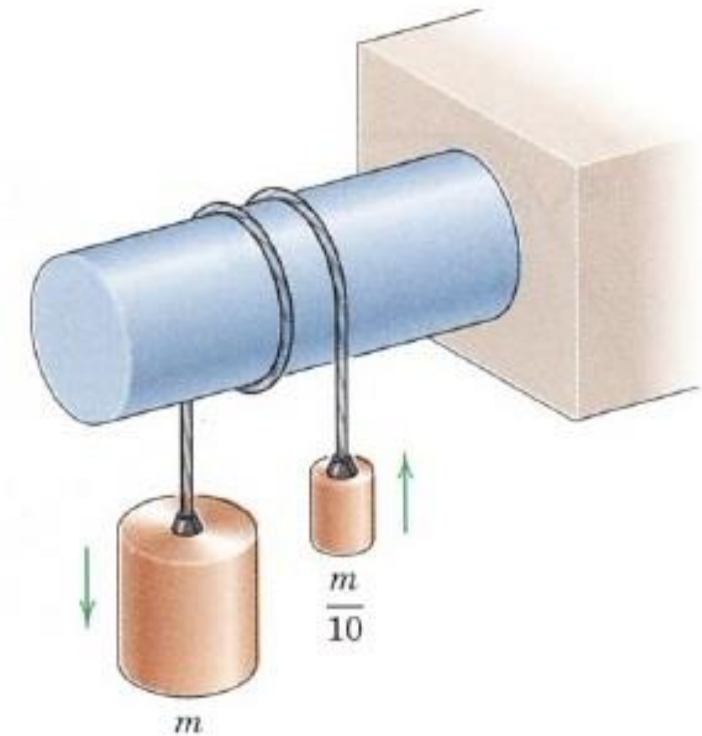
Example: What is the minimum coefficient of friction μ between the rope and the fixed shaft which will prevent the unbalanced cylinders from moving?



Ans: μ=0.22

Rope Friction: Problem 2

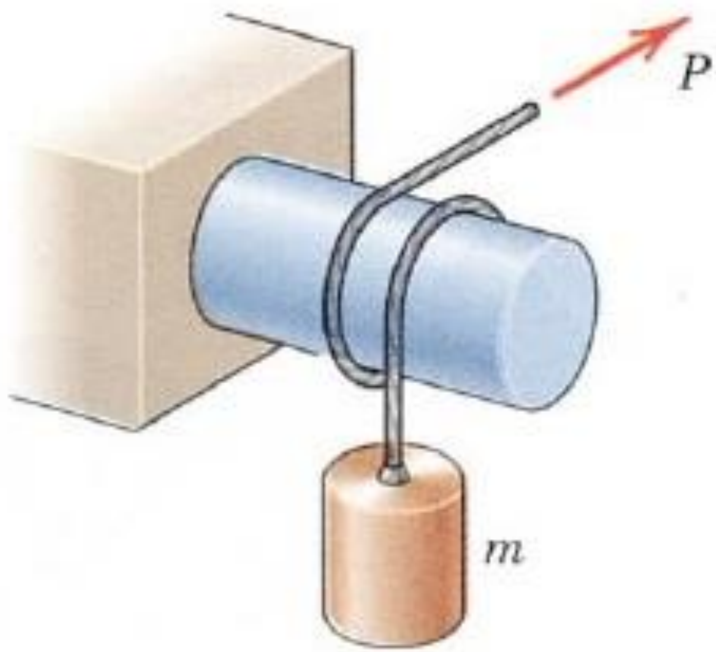
Example: It is observed that the two cylinders will remain in slow steady motion as indicated in the drawing. Determine the coefficient of friction μ between the chord and the fixed shaft.



Ans: μ=0.244

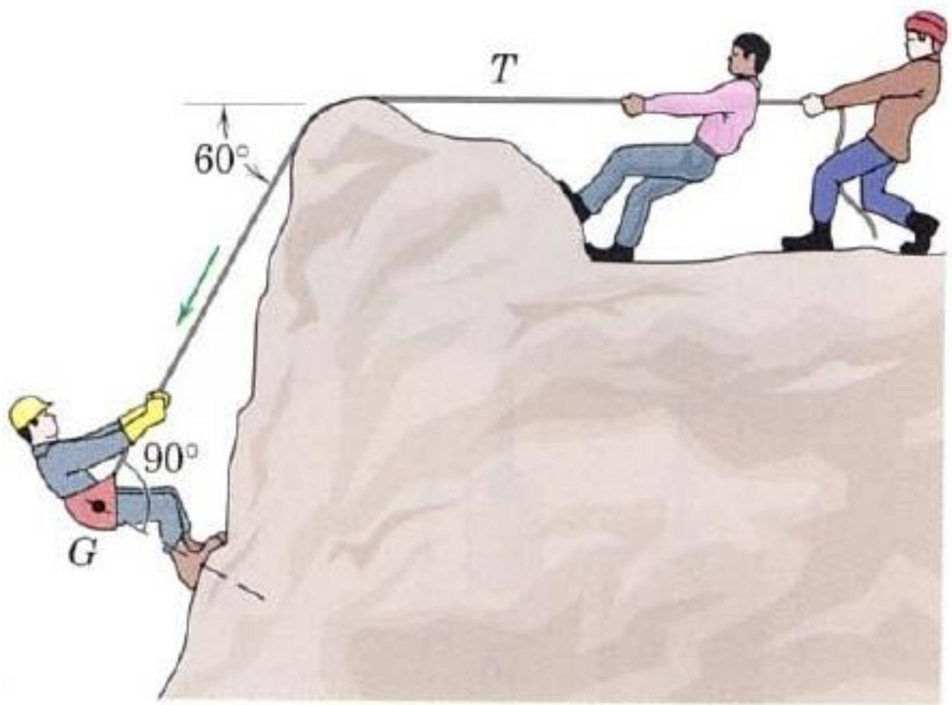
Rope Friction: Problem 3

Example: A force P = mg/6 is required to lower the cylinder at a constant slow speed with the cord making $1\frac{1}{4}$ turns around the fixed shaft. Calculate the coefficient of friction μ between the cord and that shaft.



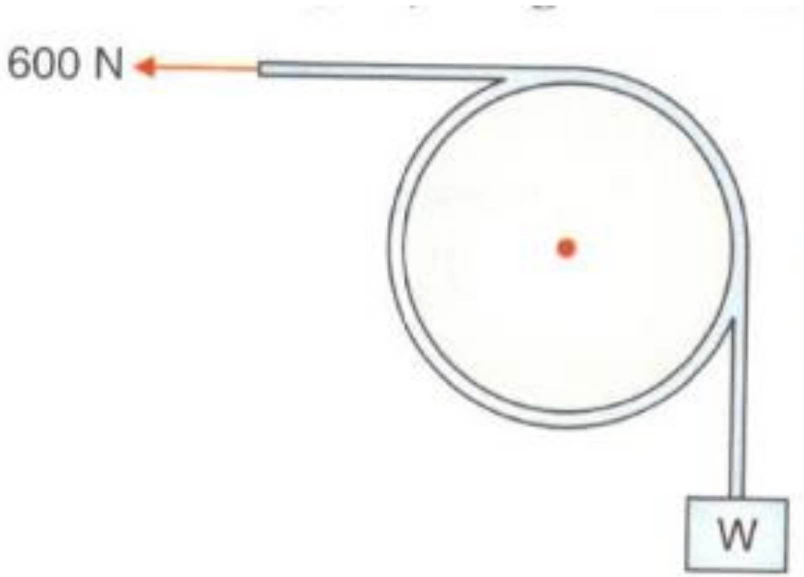
Rope Friction: Problem 4

Example: A 70 Kg rock climber is lowered over the edge of the cliff by his two companions, who together exert a horizontal pull T of 36 Kg on the rope. Compute the coefficient of friction μ between the rope and the rock.



Rope Friction: Problem 5

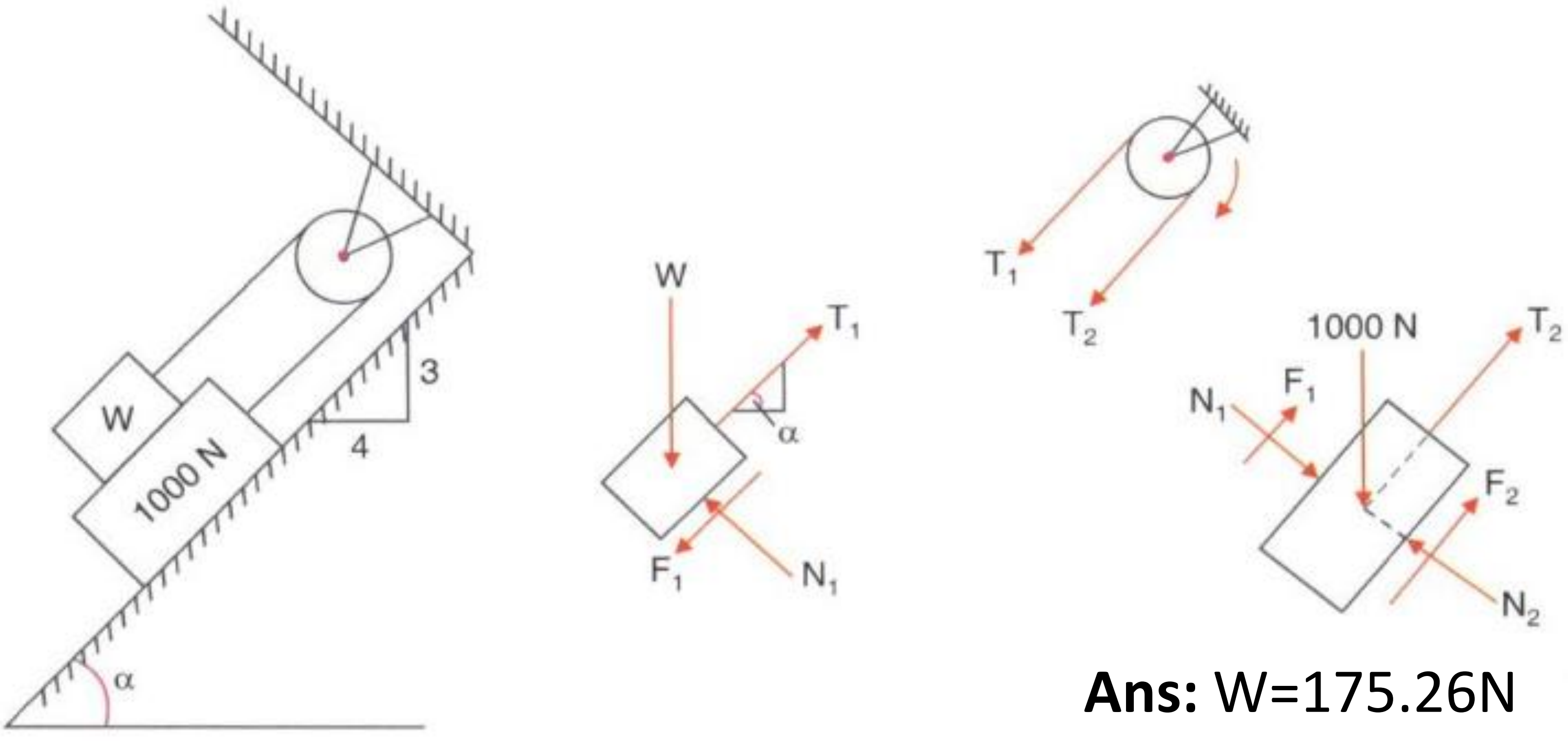
Example: A rope making $1\frac{1}{4}$ turns around a stationary horizontal drum is used to support a weight W. If the coefficient of friction is 0.3, what range of weight can be supported by exerting a 600N force at the other end of rope?



Ans: 56.87N to 6330.43N

Rope Friction: Problem 6

Example: In the following figure, the coefficient of friction between the rope and the fixed drum is 0.2 and between other surfaces of contact is 0.3. Determine the minimum weight W to prevent downward motion of the 1000N block.



(a) (b)

Ans: W=175.26N

Summary

- Friction is the force resisting the relative motion of solid surfaces, fluid layers and material elements sliding against each other
- Based on the concept of rope friction, the problems are solved