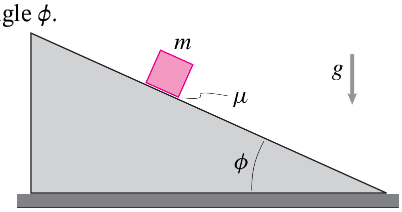
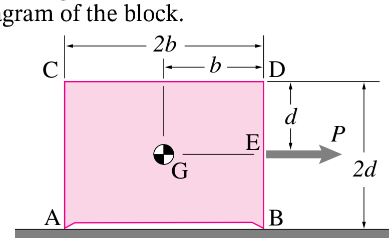
2.4 Contact and friction

2.4.1 A block on an inclined plane. A block of mass m sits on an inclined plane. The coefficient of friction between the block and the plane is μ. Draw the free-body diagram of the block and write the expression for the force(s) applied by the incline on the block in terms of incline angle ϕ.



Problem 2.4.1

2.4.2 A block of mass m sits on a surface supported at points A and B. A horizontal force P acts at point E. There is gravity. The block is sliding to the right. The coefficient of friction between the block and the ground is μ. Draw a free-body diagram of the block.

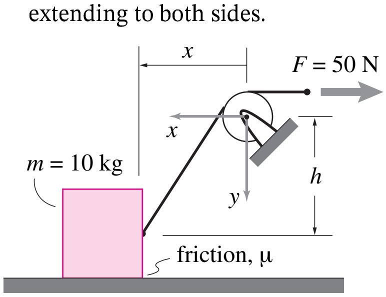


Problem 2.4.2

2.4.3 A block sliding on level ground. A block of mass 10 kg is pulled by an inextensible cable over the pulley.

a) Assuming the block remains on the floor, draw a free-body diagram of the block. (There are various correct answers depending how you model the interaction of the bottom of the block with the ground. See fig. 2.74 on page 193)

b) Draw a free-body diagram of the pulley with a little bit of the cable extending to both sides.

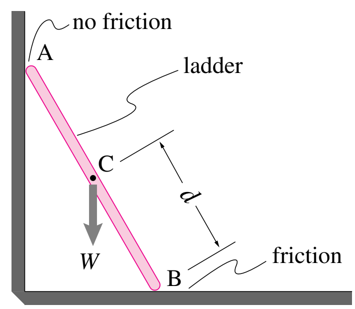


Problem 2.4.3

2.4.4 A ladder standing still. A ladder of mass m rests against a frictionless wall and a floor with more than enough friction to prevent slip. There is gravity.

a) Draw a free-body diagram of the ladder.

b) What is force on the ladder at point B? Find the direction of this force at B assuming the coefficient of friction to be μ and the ladder to be in a state of impending slip. Does the direction of the net force at B depend on the relative positions of A and B (again, assuming impending slip)?

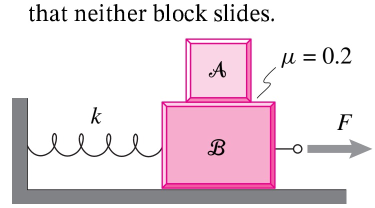


Problem 2.4.4

2.4.5 For the system shown in the figure draw free-body diagrams of each mass separately and of the system of two blocks.

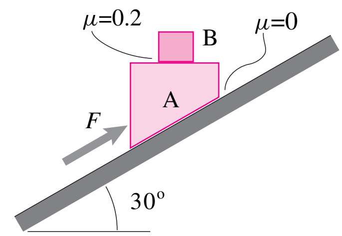
a) Assume there is friction with coefficient μ. At the time of interest block $\mathcal{B}$ is sliding to the right and block $\mathcal{A}$ is sliding to the left relative to $\mathcal{B}$.

b) Assume there is so much friction that neither block slides.



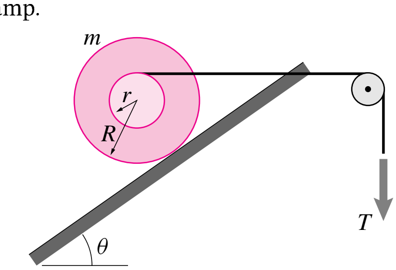
Problem 2.4.5

2.4.6 Two blocks A and B, with mass m_A and m_B respectively, are held on an inclined plane as shown in the figure. Draw a free-body diagram of block A and find the net force acting on the block.



Problem 2.4.6

2.4.7 A spool rolling up an inclined plane. Draw a free-body diagram of the spool shown, including a bit of the rope. Assume the spool does not slip on the ramp.

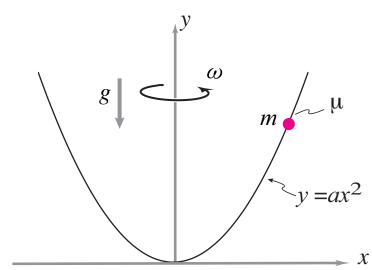


Problem 2.4.7

2.4.8 A bead riding on a rotating wire. A bead of mass m is free to slide on a wire bent in the shape of a parabola. The coefficient of friction between the wire and the bead is μ. The wire rotates about the y-axis. A snapshot during the motion captures the wire in the xy-plane. At this instant, assume the position of the bead to be (x, y).

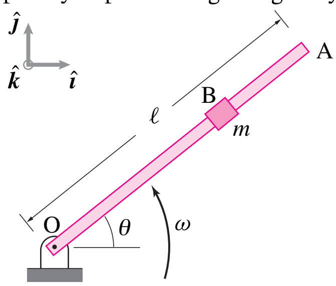
a) Draw a free-body diagram of the bead.

b) Write the vector expression for the force on the bead from the wire. [Hint: you need to find the normal vector to the wire at the position of the bead.]



Problem 2.4.8

2.4.9 A collar sliding up a rotating rod. A uniform rod OA of negligible mass rotates in the plane about point O. A collar B of mass m slides on the rod but faces friction with coefficient $\mu = 0.1$. At the instant shown, draw the free-body diagram of the rod and the collar separately evaluating the force of their interaction as explicitly as possible. Ignore gravity.

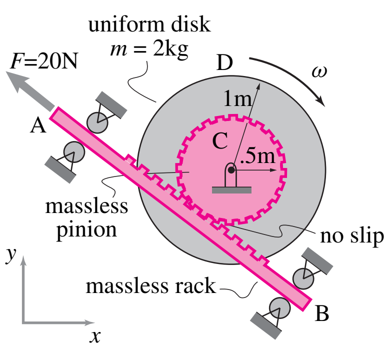


Problem 2.4.9

2.4.10 A rack and a pinion. In the rack and pinion arrangement shown in the figure, the pinion C is welded to the disk D. The rack is pulled up with a force F. As a result the pinion rotates clockwise along with disk D. Assume that the rack and the pinion mesh perfectly together and that there is no slip between them. You can include or ignore gravity.

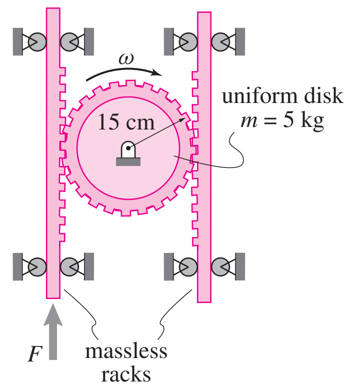
a) Draw a free-body diagram of the rack.

b) Draw a free-body diagram of the pinion along with the disk D.



Problem 2.4.10

2.4.11 Two racks with one pinion A pinion of mass 5 kg and radius 15 cm meshes with two massless racks. The left rack is pushed up with force F making the pinion rotate clockwise. Assuming no slipping between the meshing teeth, draw the free-body diagrams of each rack and the pinion separately. Ignore gravity.



Problem 2.4.11

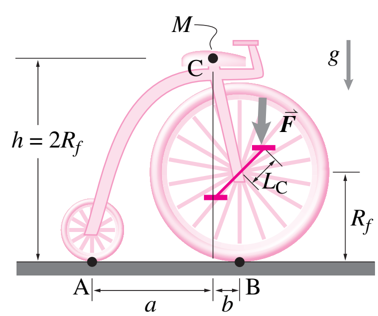
2.4.12 A bicycle with unequal wheels. For the bicycle shown in the figure, assume the mass of the bicycle (and possibly the rider) to be a point mass located at C. A vertical downward force F is applied on the front pedal.

a) Draw a free-body diagram of the front wheel.

b) Draw a free-body diagram of the back wheel.

c) Draw a free-body diagram of the entire bicycle.

d) What assumptions have you made in modeling the interaction force of the ground with the wheels?



Problem 2.4.12