A box of uniform density weighing 100 newtons moves in a straight line with constant speed along a horizontal surface. The coefficient of sliding friction is 0.4 and a rope exerts a force $F$ in the direction of motion as shown above.

a. On the diagram below, draw and identify all the forces on the box.

b. Calculate the force $F$ exerted by the rope that keeps the box moving with constant speed.

c. A horizontal force $F'$, applied at a height $5/3$ meters above the surface as shown in the diagram above, is just sufficient to cause the box to begin to tip forward about an axis through point $P$. The box is 1 meter wide and 2 meters high. Calculate the force $F'$. 

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Two masses, $m_1$ and $m_2$, are connected by light cables to the perimeters of two cylinders of radii $r_1$ and $r_2$, respectively, as shown in the diagram above with $r_1 = 0.5$ meter, $r_2 = 1.5$ meters, and $m_1 = 20$ kilograms. Determine $m_2$ such that the system will remain in equilibrium.

A long, uniform rod of mass $M$ and length $L$ is supported at the left end by a horizontal axis into the page and perpendicular to the rod, as shown above. The right end is connected to the ceiling by a thin vertical thread so that the rod is horizontal. Express the answers to all parts of this question in terms of $M$, $L$, and $g$.

a. Determine the magnitude and direction of the force exerted on the rod by the axis.

b. If the breaking strength of the thread is $2Mg$, determine the maximum distance, $r$, measured from the hinge axis, that a box of mass $4M$ could be placed without breaking the thread.
C1999M3. As shown above, a uniform disk is mounted to an axle and is free to rotate without friction. A thin uniform rod is rigidly attached to the disk. A block is attached to the end of the rod. Properties of the rod, and block are as follows.

- Rod: mass = m, length = 2R
- Block: mass = 2m
- Disk: radius = R

The system is held in equilibrium with the rod at an angle $\theta_o$ to the vertical, as shown above, by a horizontal string of negligible mass with one end attached to the disk and the other to a wall. Determine the tension in the string in terms of m, $\theta_o$, and g.

C2008M2.

The horizontal uniform rod shown above has length 0.60 m and mass 2.0 kg. The left end of the rod is attached to a vertical support by a frictionless hinge that allows the rod to swing up or down. The right end of the rod is supported by a cord that makes an angle of 30° with the rod. A spring scale of negligible mass measures the tension in the cord. A 0.50 kg block is also attached to the right end of the rod.

(a) On the diagram below, draw and label vectors to represent all the forces acting on the rod. Show each force vector originating at its point of application.

(b) Calculate the reading on the spring scale.

(c) Calculate the magnitude of the force exerted by the hinge on the rod.
Supplemental Problem

The diagram below shows a beam of length 20.0 m and mass 40.0 kg resting on two supports placed at 5.0 m from each end.

A person of mass 50.0 kg stands on the beam between the supports. The reaction forces at the supports are shown.

(a) State the value of $N_1 + N_2$

(b) The person now moves toward the X end of the beam to the position where the beam just begins to tip and reaction force $N_1$ becomes zero as the beam starts to leave the left support. Determine the distance of the girl from the end X when the beam is about to tip.