Midterm 3

1. A pole of length 4.5 m and mass 16 kg is attached to a pivot on the ceiling. It is released from rest at an initial angle of 35°, as shown at left. When the pole reaches the bottom of its swing, a circus performer of mass 36 kg grabs onto the end of the pole. **What is the maximum angle of the upward swing of the pole with the circus performer on the end of the pole?** The moment of inertia of the pole is \( \frac{1}{3}M\ell^2 \), where \( M \) is the mass of the pole and \( \ell \) is its length. Treat the circus performer as a point mass and neglect friction between the circus performer and the floor.
2. A bicycle wheel of mass $M$ and radius $R$ is initially at rest on a horizontal surface. It is accelerated by a constant horizontal force $F$ acting on the axle as shown. The moment of inertia of the wheel is $MR^2$. Assume the wheel rolls without slipping.

(a) (18 points) Use the work-energy theorem to find the horizontal velocity $v$ as a function of the distance $d$ travelled by the wheel.

(b) (15 points) Using your result for part (a), find the horizontal acceleration $a$ of the wheel. Hint: the answer is not $a = F/M$!

3. A balance scale consists of a rod of mass 0.15 kg and length 45 cm that can rotate freely about a pivot at the center. A weight with mass 55 g is placed on one end of the rod. The system is released at rest with the rod horizontal, as shown at left. Find the angular velocity of the rod about the center when the rod makes an angle of $15^\circ$ with the horizontal. Treat the weight as a point mass and assume that it does not slide on the scale. The moment of inertia of a rod of mass $M$ and length $\ell$ for rotation about its center is $\frac{1}{12}M\ell^2$. 