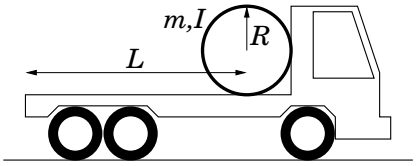
NYU Physics I—rolling

A heavy round pipe of mass m, radius R, and moment of inertia I sits at rest on the horizontal bed of a parked truck, a distance L from the end of the truck bed. It isn't properly secured!

At time $t = 0$, the truck starts to accelerate forwards with acceleration a, at which point the pipe begins to roll without slipping on the truck bed. Give all your answers with respect to the stationary ground, *not* the moving truck.



(a) Forget the truck for a moment. Imagine you have a pipe of radius R rolling (without slipping) on the ground at (center-of-mass) speed v with respect to the ground. What is the relationship between the speed v of the pipe and the angular speed ω of the pipe and why?

(b) Now, back to the truck: During the acceleration, when the truck is moving at speed v_t and the pipe is moving at speed v_p (with respect to the ground) and the pipe is spinning at angular speed ω_p, what is the condition (that is, the equation relating v_t, v_p, ω_p and R) for rolling without slipping on the truck bed? *Think about the movement of the pipe relative to the truck bed.*

(c) Draw a free body diagram for the pipe, showing all forces, for $t > 0$.

(d) Which way does the pipe accelerate (relative to the ground)? Will its acceleration be greater or less than a? Which way does it start to spin? That is, anticipate the dynamics.

(e) What is the acceleration of the pipe? That is, solve the equations you have.

(f) (Optional!) When (at what time) does the pipe fall off the truck?