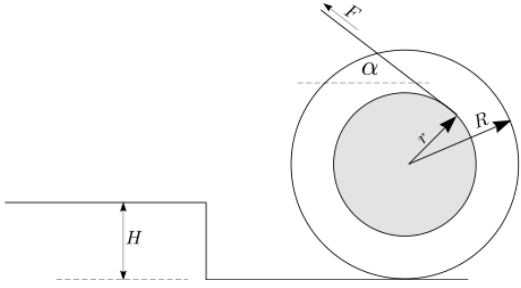
1. Spool ***(12 points)*** A spool with inner radius r and outer radius R lies on a horizontal table; the axis of the spool is horizontal. A weightless rope is wound around the inner part as shown in the picture. The loose end of the rope makes an angle α with the horizontal (the angle α can be also negative). The moment of inertia of the spool is J and mass — M. In what follows you may assume that the spool rolls on the table without slipping.



i) (2 pts) We pull the loose end of the rope with velocity u (parallel to the loose part of the rope; that loose part can be thought to be very long). What is the velocity of the spool?

ii) (3 pts) Suppose now that the spool is at rest, and we apply force F to the loose end of the rope (parallel to the loose part of the rope). What is the acceleration of axis of the spool?

iii) (2 pts) How large does the coefficient of friction μ need to be (as a function of α) to ensure that there is no slipping between the spool and the table?

iv) (1.5 pts) Now the spool rolls, again, with velocity u; however there is no rope. The spool hits a threshold of height H (see Figure); the impact is perfectly inelastic. What is the speed v of the spool immediately after the impact?

v) (1.5 pts) What is the speed w of the spool after rolling over the threshold? Assume that u is such that the spool will roll over the threshold without losing contact with its edge.

vi) (2 pts) If the speed u is too large, $u > u_0$, the spool will jump up and lose contact with the edge of the threshold. Determine u_0.