

Reading: Chapters 1.3-6,2.1-2

Problems:

1. Goldstein, Problem 1.6.
2. Consider the rocket from Problem 1.13 in Goldstein. The term $-v' dm/dt$ in the rocket equation is called a thrust. For the rocket accelerating outside of a gravitational field ($g = 0$), find the efficiency as a ratio of the final kinetic energy to the work done by the thrust, in terms of the Tsiolkovsky number, the ratio of the initial to final rocket mass. Discuss qualitatively the dependence of the efficiency on the Tsiolkovsky number.

3. Goldstein, Problem 1.14.

4. Problem from August '02 Subject Exam:
A steel cylinder of mass M , radius R , and moment of inertia $I = \frac{1}{2}MR^2$ rests across the width of a flatbed truck. The flatbed floor has length L .

(i) As the truck accelerates at a constant acceleration of $a = \frac{1}{2}g$ in the positive x direction, the pipe starts to roll without slipping (due to static friction force).

(a) Write down the condition for rolling without slipping. (Use the angle of rotation θ and linear coordinate of the center of the pipe x with respect to the ground as variables.)

(b) Plot qualitatively the velocities $v = \dot{x}$ and $\omega = \dot{\theta}$ as a function of time. (It is useful to plot v and ωR alongside each other on the same plot.)

(c) What are the linear and angular velocities (magnitude and direction) of the pipe just before it falls off from the truck?

(ii) After the pipe hits the ground, its motion will, at first, consist of rolling and skidding.

(a) If the coefficient of kinetic friction between the moving cylinder and the level ground is $\mu_k = \frac{1}{4}$, what are the linear and angular accelerations (\dot{v} , $\dot{\omega}$) while the cylinder is skidding? Use these results to extend the velocity plot of part (i.b) above.

(b) When the cylinder ceases to skid, what are its linear and angular velocities? (The above graph can be quite helpful here.)