

# 1 Braking Disk

A disk with mass  $m$  and radius  $R$  is spinning with angular velocity  $\omega_0$ .

- (a) How much friction force would you need to apply to the rim in order to bring a disk to a halt in time  $T_0$ ?
- (b) *Sensemaking: Check Dimensions* First, indicate the dimensions you think your answer should have. Then, check that your answer has the expected dimensions.
- (c) *Sensemaking: Evaluate the Functional Behavior* First, indicate how you expect the friction force to vary if you varied the initial angular velocity and the stopping time. Then, check that your answer has the expected functional behavior.

# 2 Linear Air Drag Power Series

For a projectile with linear drag, the vertical component of the position looks like:

$$y(t) = \frac{m}{b} \left( v_{y,0} + \frac{mg}{b} \right) \left( 1 - e^{-bt/m} \right) - \left( \frac{mg}{b} \right) t + y_0$$

- (a) **Approximate with a Power Series:** Do a power series expansion of the vertical component of the position to third order with respect to the constant  $b$ .
- (b) **Consider a Special Case:** Show that if the air drag goes to zero, your expansion gives you the equation for the vertical component of the position if there is no air drag.

# 3 Cycle Racer

(modified from Taylor 2.25)

Consider a cyclist moving in a straight line and coasting to a stop under the influence of a quadratic air resistance  $\vec{F}_{drag} = -cv^2\hat{v}$ .

- (a) **Anticipate the functional behavior:** Before doing any calculation, sketch (by hand) what you expect the velocity vs time and the position vs. time graph to look like. Label interesting regions or points.
- (b) **Calculate:** Starting with Newton's 2nd Law, find the velocity and position of the cyclist as a function of time.
- (c) **Dimensions:** Check the dimensions of the answers.

(d) *Examine the Behavior of Functions:* Plot the velocity and position as functions of time. Do your plots make conceptual sense? Compare your plots to the your hand-sketches and comment on similarities and differences.

## 4 Quadratic Drag with Gravity

(modified from Taylor 2.35)

Consider an object dropped near the surface of Earth and subject to a quadratic drag force from the air.

(a) **Anticipate the functional behavior:** Before doing any calculation, sketch (by hand) what you expect the velocity vs time and the position vs. time graph to look like. Label interesting regions or points.

(b) **Calculate:** Find the velocity as a function of time (the equation is in the textbook but I want to see the details of the calculations). Be sure to do any integrals involved.

(c) *Examine the Behavior of Functions:* Plot the velocity and explain the features of this plot. Compare your plot to your hand-sketchn and comment on similarities and differences.

(d) **Calculate:** Find the position as a function of time (again, the equation is in the textbook but I want to see the details of the calculation). Be sure to do any integrals involved.

(e) *Examine the Behavior of Functions:* Plot the position and explain the features of this plot. Compare your plot to your hand-sketchn and comment on similarities and differences.