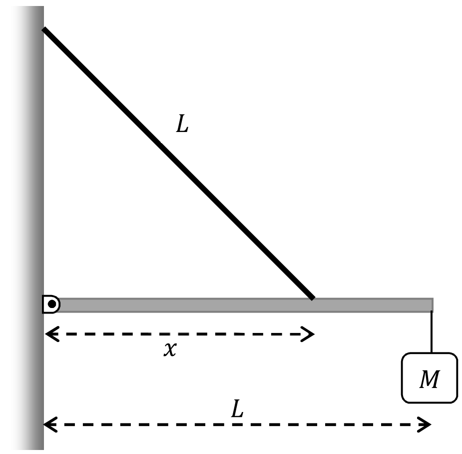
Ch12 Update

12.1½ Consider a rod mounted to a wall using a pivot with negligible friction. The rod has length L and mass m. A support cable with equal length (but negligible mass is used to support the rod). The support cable can be connected to the rod at any distance x from the pivot as shown. Mass $M \neq m$ hangs on a string from the end of the rod. Assume x, L, m & M are givens (as is the magnitude of freefall acceleration g).



a) In general, tension in a string is *not always* equal to the weight of the mass hanging on it. Why is it ok, in *this* special case, to say the tension in the *string* (not the support cable) is Mg?
b) Write down sum of torques about the pivot.
c) Write down sum of forces in the x-direction using a standard coordinate system (positive x is to the right).
d) Write down sum of forces in the y-direction using a standard coordinate system (positive y is upwards).
e) Determine the tension *in the support cable* in terms of the givens. Express your answer as both a vector in Cartesian form ($\vec{T} = T_x\hat{\imath} + T_y\hat{\jmath}$) and in polar form (magnitude T & direction θ_T with sketch).
f) THINK: does your previous answer make sense when $x = 0$ or $x = L$? Consider the physical scenario for those two cases and try to imagine if tension should be large or small?
g) Determine the reaction force at the pivot in terms of the givens. Express your answer as both a vector in Cartesian form ($\vec{R} = R_x\hat{\imath} + R_y\hat{\jmath}$) and in polar form (magnitude R & direction θ_R with sketch).
h) THINK: does your previous answer make sense when $x = 0$ or $x = L$? Consider the physical scenario for those two cases and try to imagine if tension should be large or small?
i) Let $M = 4.00$ kg, $m = 1.00$ kg, $L = 1.00$ m. Create a spreadsheet tabulating T, θ_T, R & θ_R as $x = 0.05 \rightarrow 0.95$ m in increments of 0.025 m.
j) Create a simulation that draws all forces acting on the rod to scale for arbitrary $0.05\text{ m} < x < 0.95\text{ m}$. To keep it simple, start by hard coding in a value of x (say $x = 0.50$ m).

To notice:

- Polar form is nice if we want force magnitudes. Perhaps we care about tension in the support cable so we can determine an appropriate size cable for a design project.
- Cartesian form is nice when coding. Perhaps we care about conveying information visually to a co-worker, boss, or someone who hired us for contract work.
- Doing problems algebraically (instead of with one special case of numbers) allows us to quickly test a wide variety of design situations and create visualizations (plots or sims). These visualizations improve our ability communicate effectively with other people.
- With any coding example, it is important to realize the limitations of our model. For example, in this problem we expect the code will produce nonsense if the support cable connects near the left or right end of the rod ($x \approx 0$ or $x \approx L$).

Extra activities for 12.2

Create a plot of tension in the string versus the position of the $5m$ mass.
Create a simulation showing force arrows on the rod as position of the $5m$ mass goes from $0 \rightarrow L$.

Extra activities for 12.14

It would be neat to plot T vs L for this scenario.
Alternatively, create a simulation wherein force arrows acting on the rod are drawn as L gradually increases.