Helicopter retrieval equations of motion & simulation.

One way to generate an equation that governs the motion of fishermen in a rescue bucket (modeled as a particle Q) being retrieved with a relatively light straight cable B into a helicopter (modeled as a rigid body A) is to form the resultant of all forces on Q as $\mathbf{F}^Q = \text{-}m\,g\,\widehat{\mathbf{a}}_y + T\,\widehat{\mathbf{b}}_y$ and relate it to Q's mass and acceleration in N via Newton's law as $\mathbf{F}^Q = m\,{}^N\mathbf{a}^Q$, i.e.,

$$\text{-}m\,g\,\widehat{\mathbf{a}}_y + T\,\widehat{\mathbf{b}}_y = m\left[\ddot{x}\,\widehat{\mathbf{a}}_x + \ddot{y}\,\widehat{\mathbf{a}}_y + (L\,\ddot{\theta} + 2\,\dot{L}\,\dot{\theta})\,\widehat{\mathbf{b}}_x + (\text{-}\ddot{L} + L\,\dot{\theta}^2)\,\widehat{\mathbf{b}}_y\right]$$

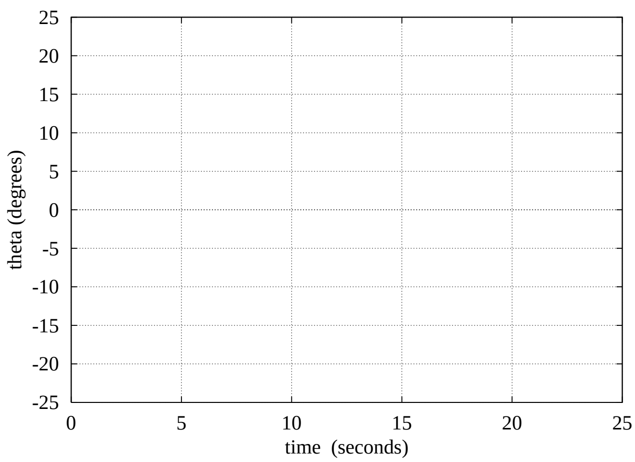
Form a **single scalar** equation of motion written in terms of symbols in the table **except** T.[1]
Result:

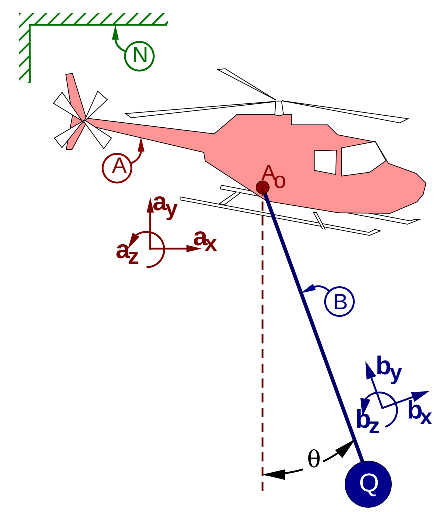
$$\qquad\qquad\qquad\qquad = 0$$

When the helicopter is **stationary** in N, Q's motion is governed by

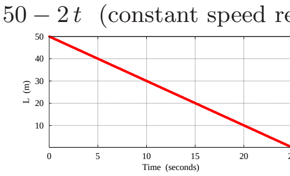
$$L\,\ddot{\theta} + 2\,\dot{L}\,\dot{\theta} + g\,\sin(\theta) = 0$$

Plot θ vs. t for $0 \le t \le 24.92$ sec. Section 2.7 shows how to numerically solve ordinary differential equations.





$L = 50 - 2\,t$ (constant speed retrieval)



Description	Symbol	Type	(Initial) value or specification
Angle between $\widehat{\mathbf{a}}_y$ and $\widehat{\mathbf{b}}_y$	θ	variable	$\theta(0) = 1^\circ \quad \dot{\theta}(0) = 0\ \frac{\text{rad}}{\text{sec}}$
Distance between Q and A_o	L	***specified***	$L(t) = 50 - 2\,t$ meters
Earth's local gravitational acceleration	g	constant	$9.8\ \frac{\text{m}}{\text{sec}^2}$

(a) I think the simulation results are intuitive. **True/False**.
(b) Similar results are associated with sucking spaghetti into your mouth. **True/False**.
(c) High-oscillation swings may be dangerous/fatal for the fishermen and helicopter. **True/False**.
(d) These high-oscillations may be related to problems encountered during a U.S. space-shuttle retrieval of a satellite in low-Earth orbit. **True/False**.
(e) I know how to specify a different function for $L(t)$ to control this system so $\theta(t)$ stays small (e.g., less than 5°). **True/False**.

[1] The single scalar equation of motion should be a 2^{nd}-order ODE involving $\ddot{\theta}$.