

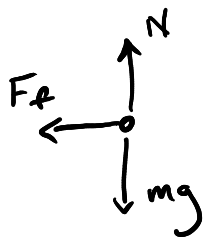
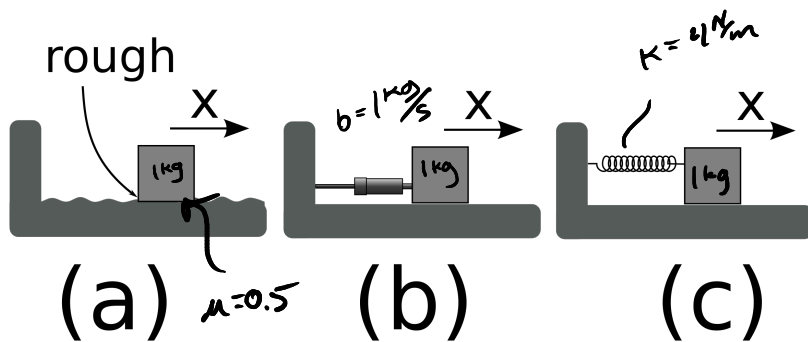


Draw FBD

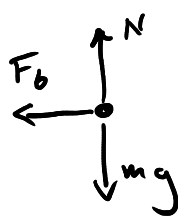
Why like that?

include drag, wind,
thrust,
gravity

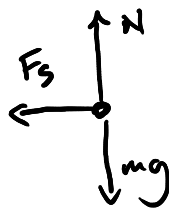
To be
con'd



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damping
 $F_b = b \cdot v = b\dot{x}$

$$F_f = \mu mg$$

$$F_b = b\dot{x} = bv$$

$$F_s = kx$$

Cooper's shorthand

$$\frac{dx}{dt} = \dot{x}$$

$$\frac{d^2x}{dt^2} = \ddot{x}$$

(a) $-\mu mg = ma$ (when $v > 0$)

(b) $-bv = ma$

(c) $-kx = ma$

given

$$x(0) = 0 \text{ m}$$

$$v(0) = 10 \text{ m/s}$$

(a) $a = -0.5 \cdot g$

$x(t) = -\frac{1}{2} \cdot 0.5 \cdot g t^2 + 10t + 0$ \rightarrow when accel is constant use kinematic eqns

$$\textcircled{b} \quad \frac{dv}{dt} = -\frac{b}{m} v$$

$$\frac{dv}{dt} \cdot \frac{1}{v} \neq \frac{d}{dt}$$

$$\frac{dv}{v} = \frac{-\frac{b}{m} \cdot v \cdot dt}{v}$$

$$\int_{v_0}^{v(t)} \frac{1}{v} \cdot dv = \int_0^t -\frac{b}{m} \cdot dt$$

$$\ln(v) - \ln(v_0) = -\frac{b}{m}(t - 0)$$

$$\ln\left(\frac{v}{v_0}\right) = -\frac{b}{m}t$$

$$\Downarrow v(t) = v_0 \cdot e^{-\frac{b}{m}t}$$

$$\begin{aligned} e^{\ln(v/v_0)} &= e^{-\frac{b}{m}t} \\ \Downarrow \\ \frac{v}{v_0} &= e^{-\frac{b}{m}t} \end{aligned}$$

$$\frac{dx}{dt} = v(t) = v_0 \cdot e^{-\frac{b}{m}t}$$

$$\int_{x(0)}^{x(t)} dx = \int_0^t v_0 e^{-\frac{b}{m}t} \cdot dt$$

$$x(t) - x_0 = -v_0 \frac{m}{b} (e^{-\frac{b}{m}t} - e^0)$$

$$x(t) = v_0 \frac{m}{b} (1 - e^{-\frac{b}{m}t})$$

note:

$$\frac{d}{dt}(e^{-bt}) = -b e^{-bt}$$

$$\int e^{-bt} = -\frac{1}{b} e^{-bt}$$