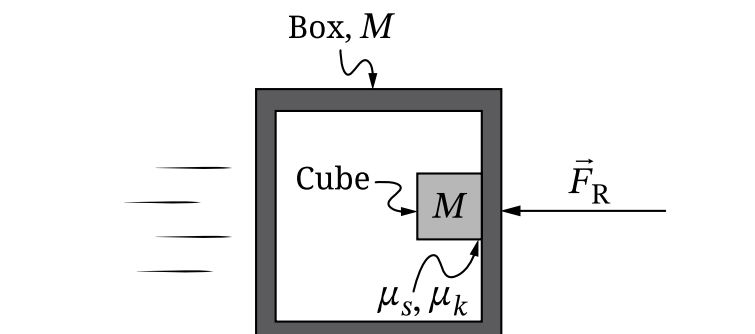


1. A box of mass M slides to the right on a horizontal surface. A small cube, also of mass M , is inside the box. The cube is against the right wall of the box and above the bottom of the box, as shown in Figure 1. The coefficients of static and kinetic friction between the cube and the wall of the box are μ_s and μ_k , respectively, where $\mu_s > \mu_k$.

Figure 1



The speed of the box is decreasing as a result of a resistive force that is exerted on the box. The resistive force $\vec{F}_R$ is modeled by $\vec{F}_R = -b\vec{v}$, where b is a positive constant and $\vec{v}$ is the velocity of the box. Friction between the box and horizontal surface is negligible.

Consider the motion of the box and cube for the following times.

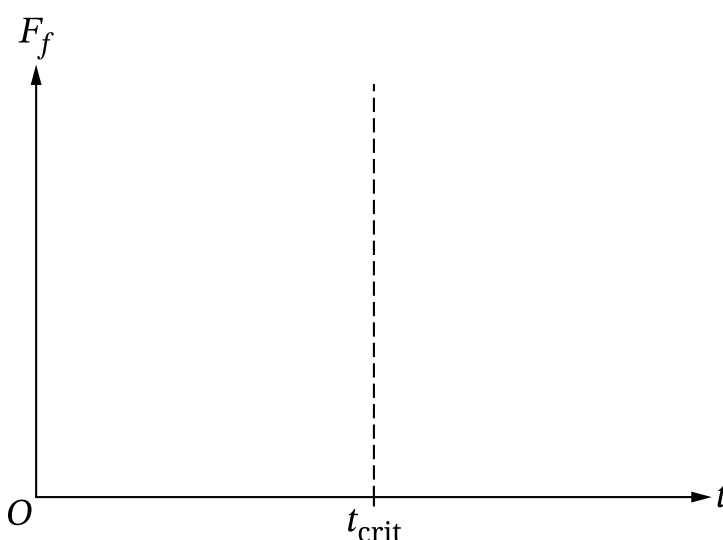
- At time $t = 0$, the box-cube system slides to the right with speed v_0 .
- For $0 \leq t < t_{\text{crit}}$, the cube remains in contact with the wall of the box at a constant height above the bottom of the box.
- At $t = t_{\text{crit}}$, the cube begins to slide downward along the wall of the box.

Part A

The magnitude of the normal force exerted on the cube by the wall of the box is F_N .

- Determine** an expression for the magnitude of the acceleration of the cube. Express your answer in terms of M , F_N , and physical constants, as appropriate.
- Derive** an expression for F_N as a function of t from $t = 0$ until immediately before the cube reaches the bottom of the box. Express your answer in terms of M , b , v_0 , t , and physical constants, as appropriate. Begin your derivation with a fundamental physics principle or an equation from the reference information.
- On the axes shown in Figure 2, **sketch** a graph of the magnitude F_f of the frictional force exerted on the cube by the wall of the box as a function of t from $t = 0$ until immediately before the cube reaches the bottom of the box.

Figure 2



Part B

Derive an expression for t_{crit} in terms of M , b , μ_s , v_0 , and physical constants, as appropriate. Begin your derivation with a fundamental physics principle or an equation from the reference information.