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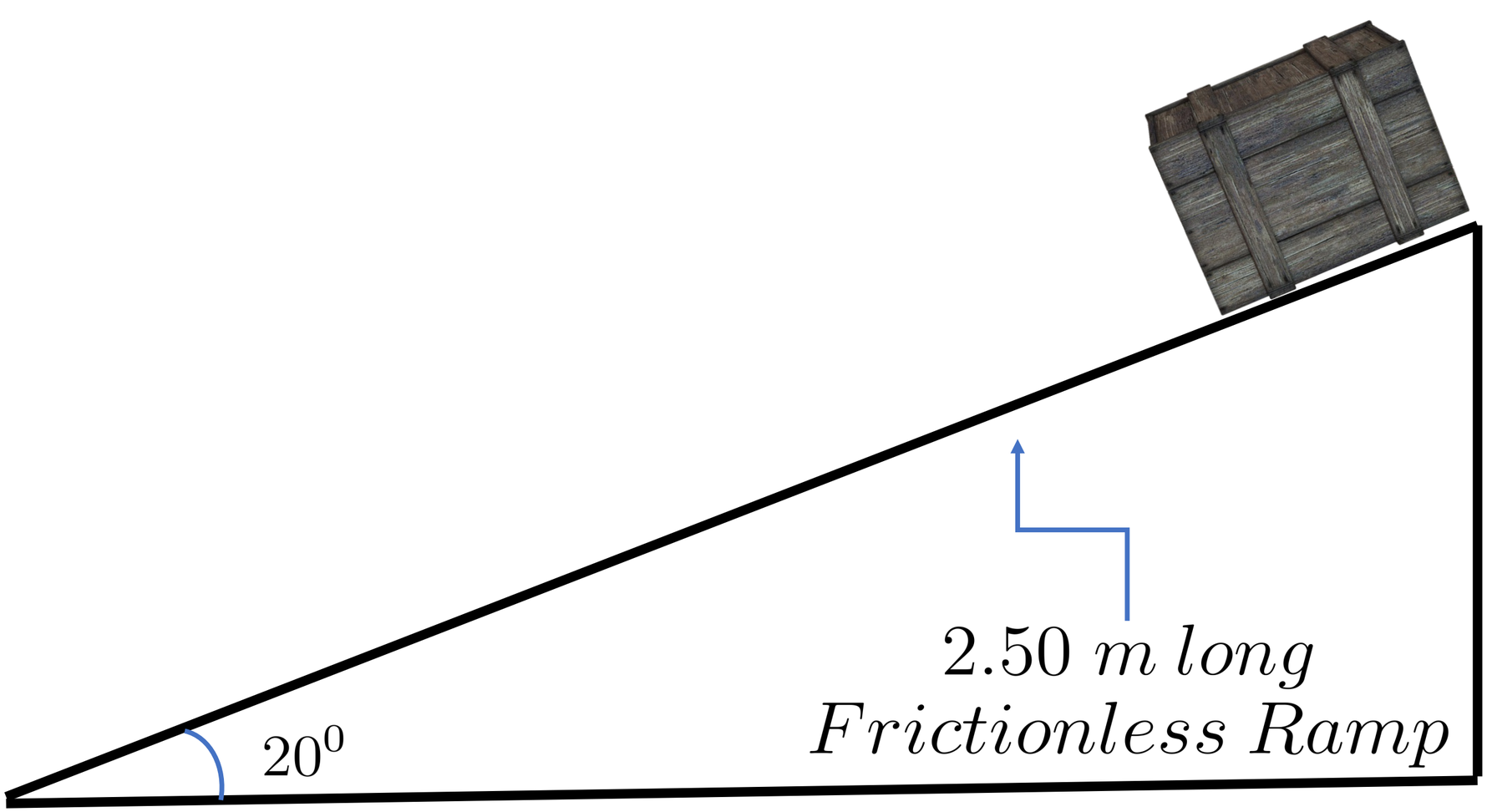
# Object Moving on a Frictionless Ramp

A wooden crate, mass 11.0 kg, is at rest at the top of a frictionless ramp as shown. The ramp is inclined $20^0$ angle and it's 2.50 m long.

A) Find all forces acting on the crate.

B) Find the acceleration of the crate.

C) Find the final velocity of the crate at the end of the ramp.



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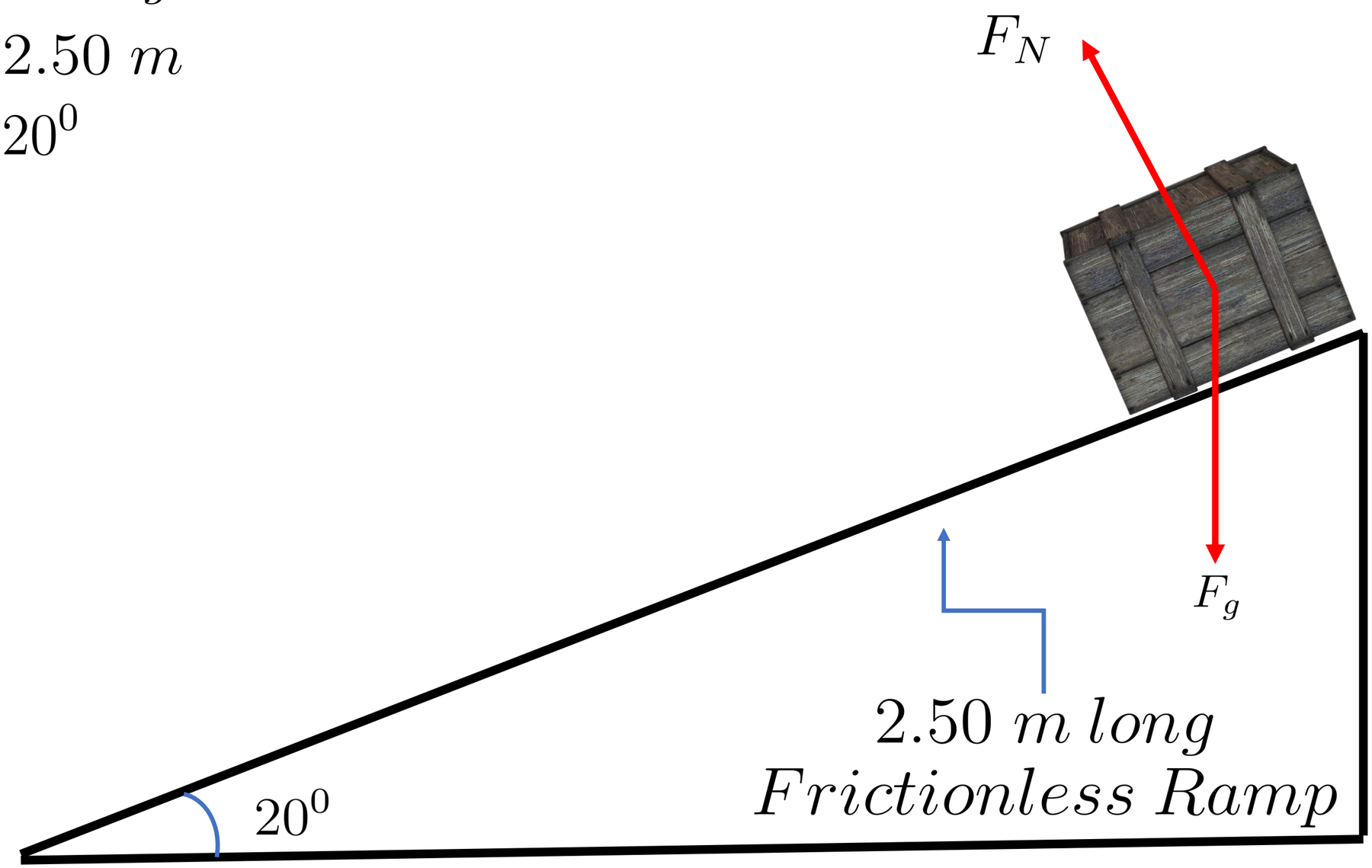
# A) Find all forces acting on the crate

$$m = 11.0\ kg$$
$$l = 2.50\ m$$
$$\theta = 20^0$$



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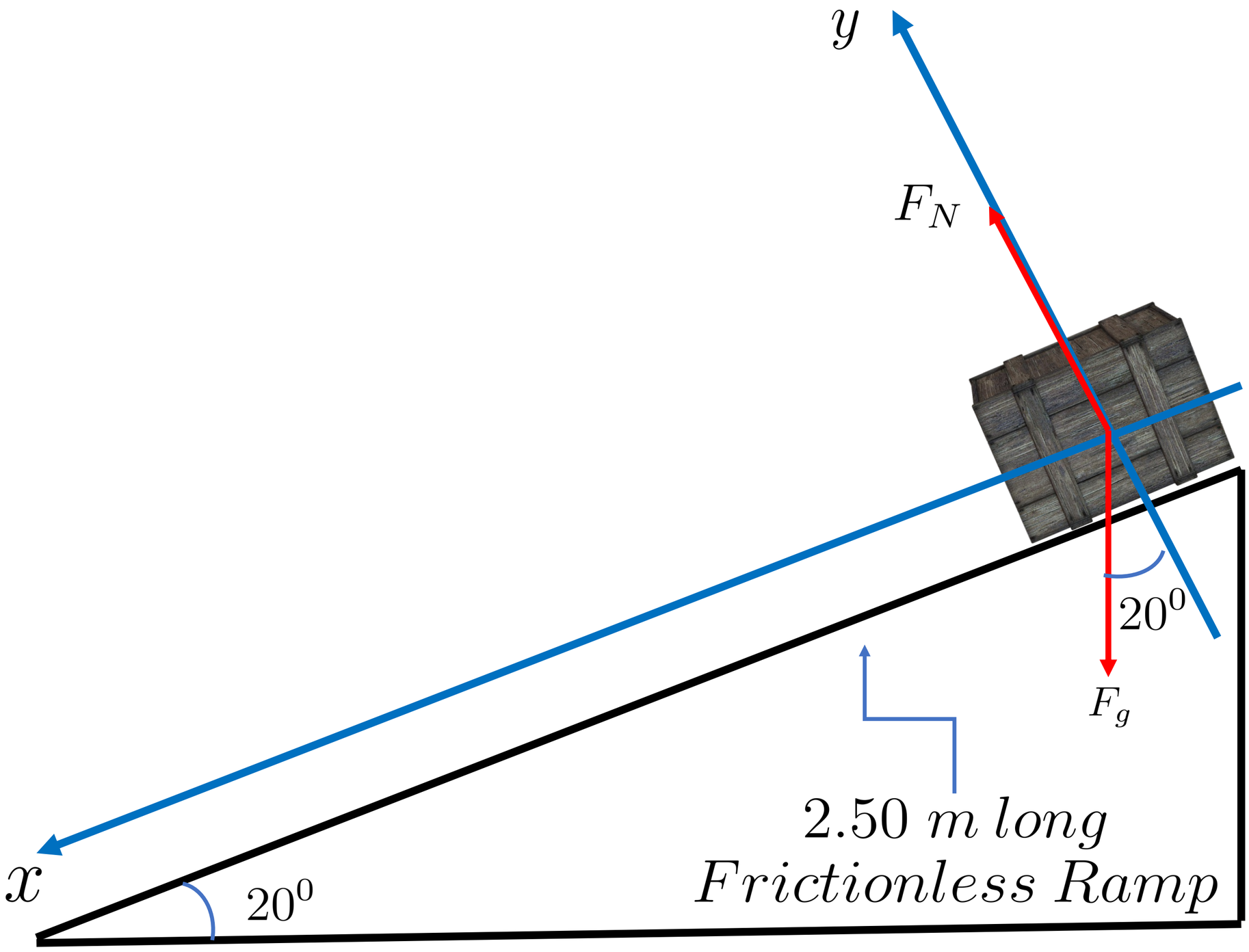
# Use a tilted coordinate system.



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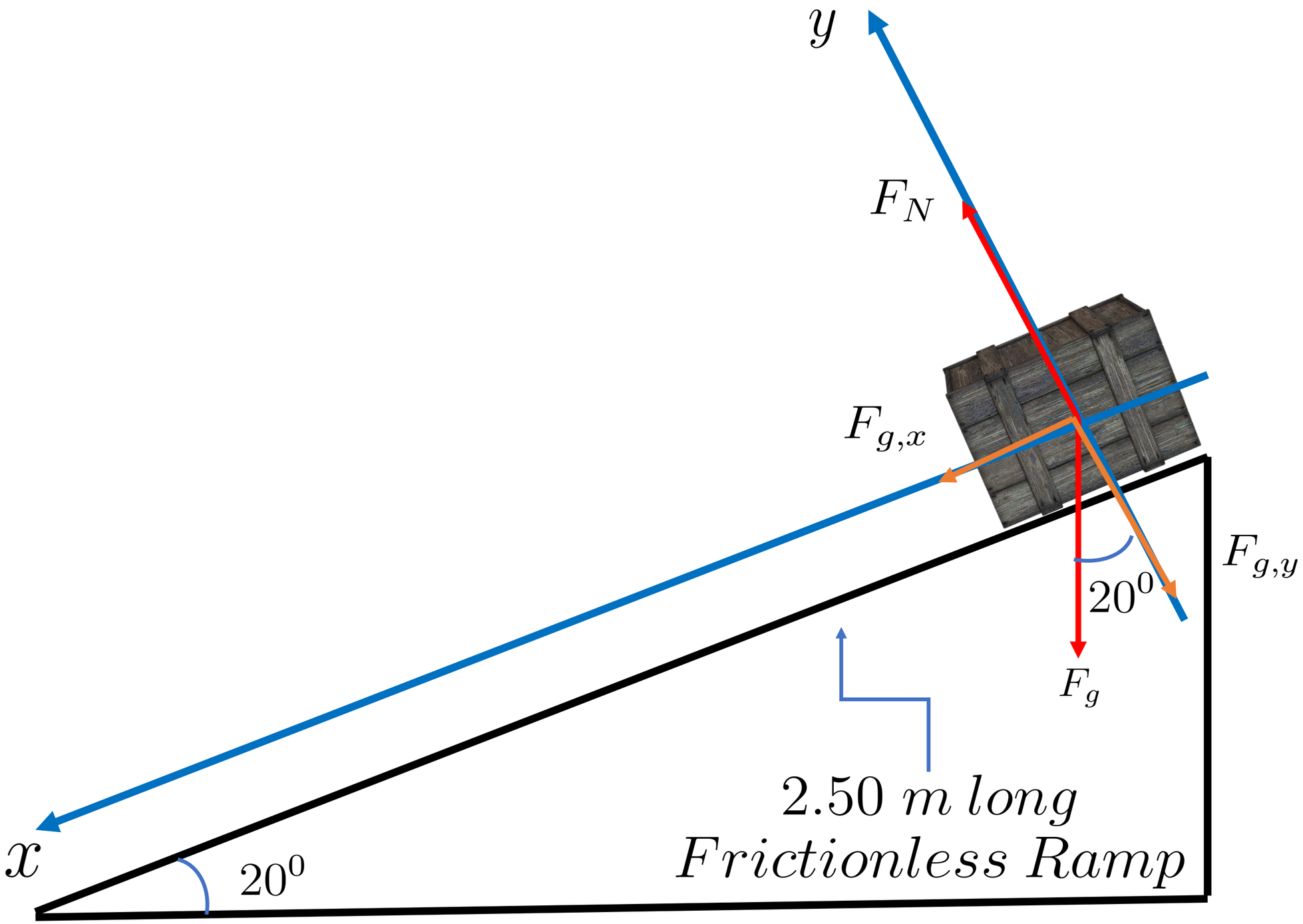
# Find x and y components of $F_g$



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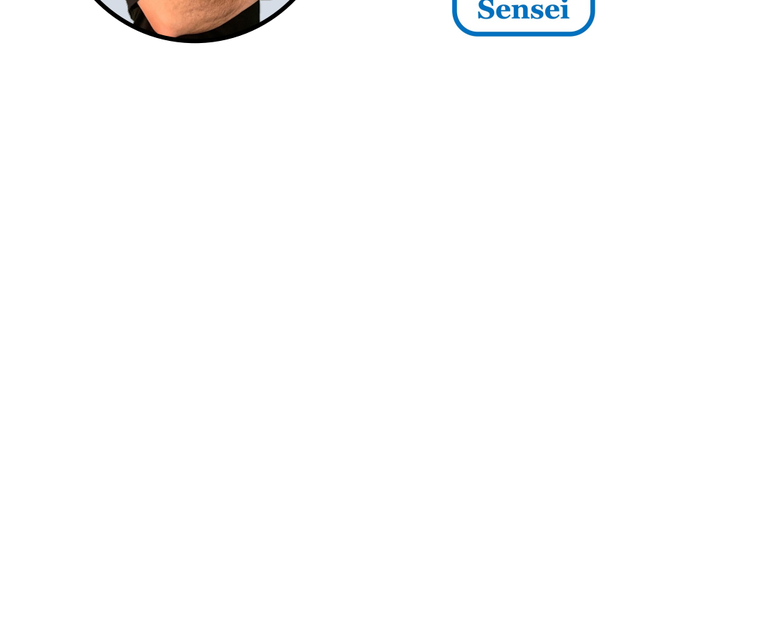
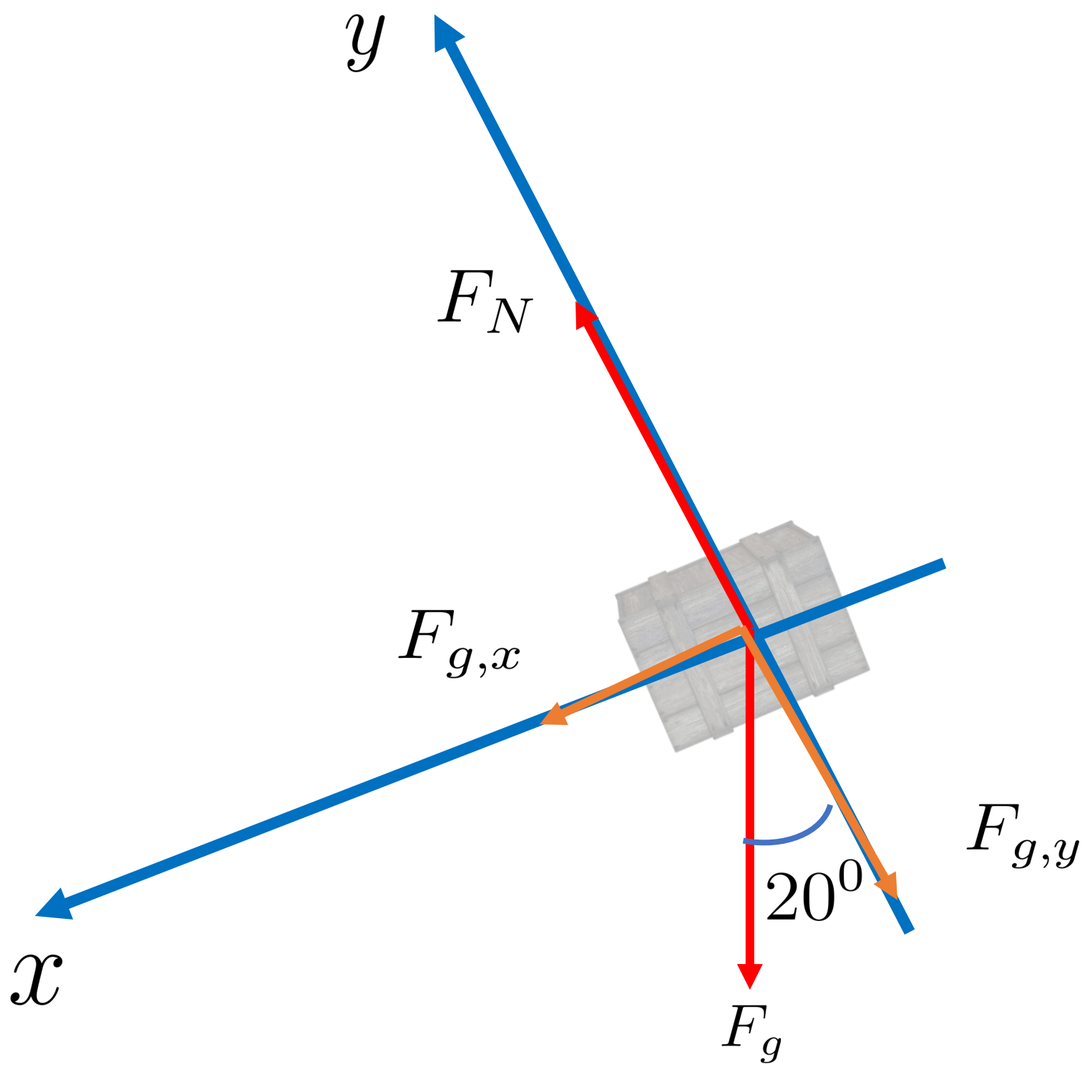
# Free Body Diagram (FBD)




$$F_{g,y} = F_g \cdot cos(20^0)$$

$$F_{g,x} = F_g \cdot sin(20^0)$$

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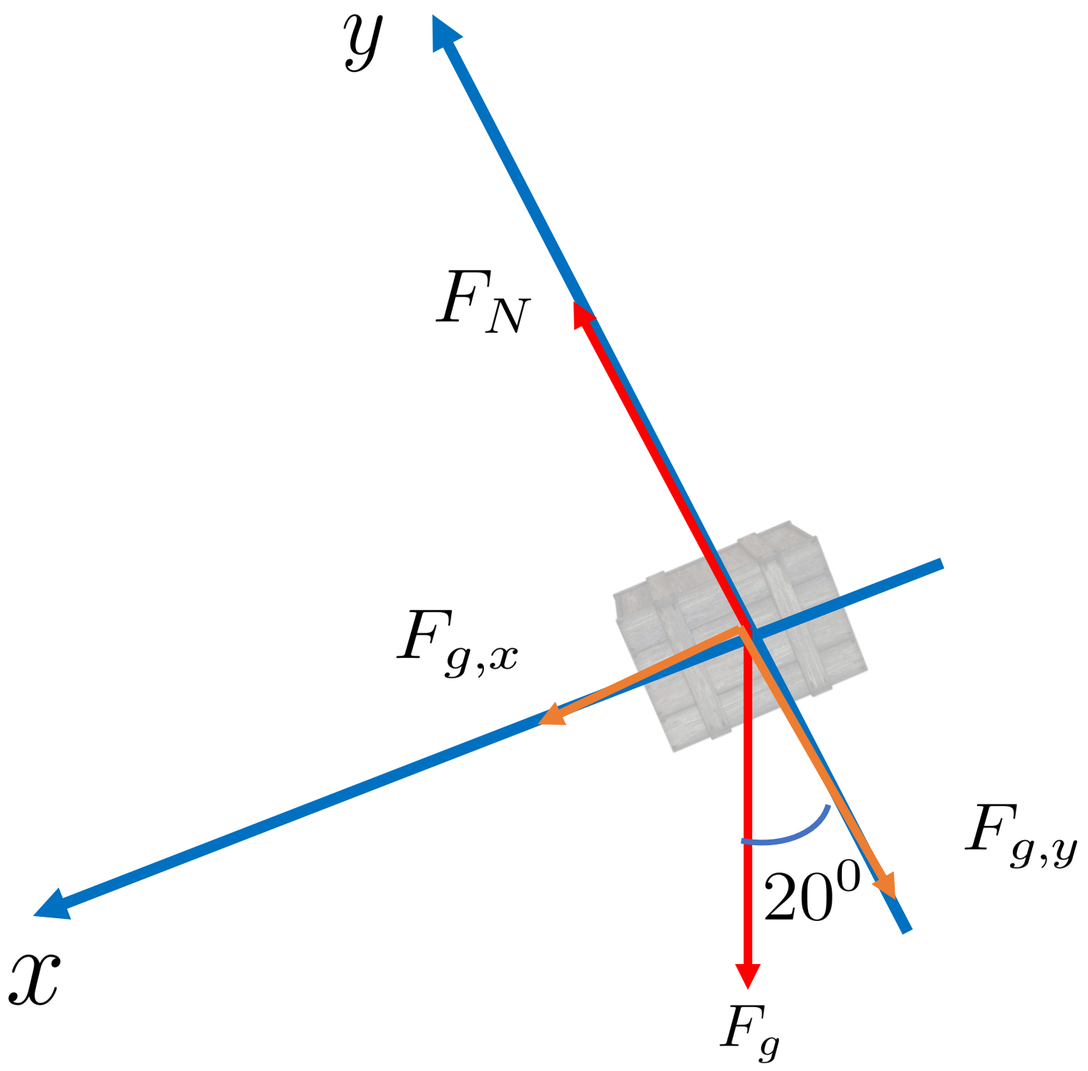
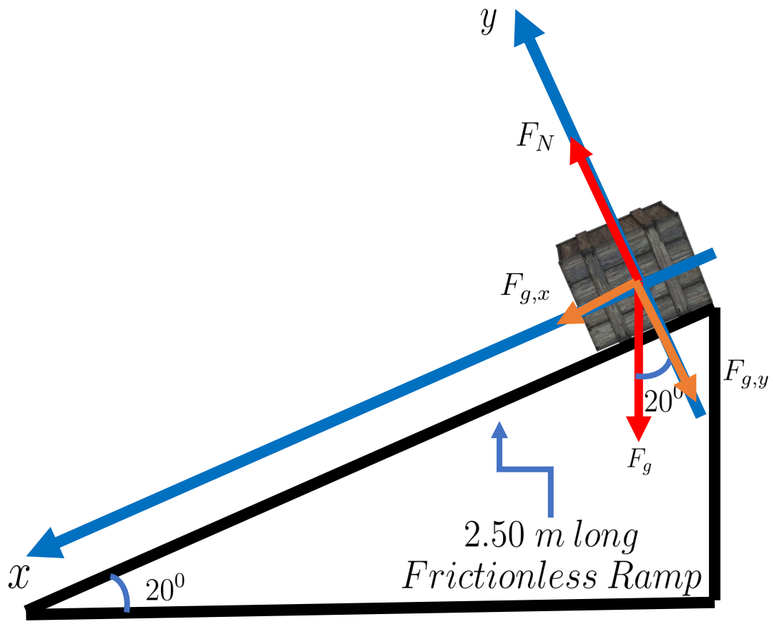
# Newton's 2nd law

$$\sum \vec{F_{ext}} = m \cdot \vec{a}$$




$$F_{g,y} = F_g \cdot cos(20^0)$$

$$F_{g,x} = F_g \cdot sin(20^0)$$

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# Newton's 2nd Law
## Y axis

$$\sum F_{ext,y} = m \cdot a_y$$

Solve for Normal Force

$$\sum F_{ext,y} = 0$$

$$F_N - F_{g,y} = 0$$

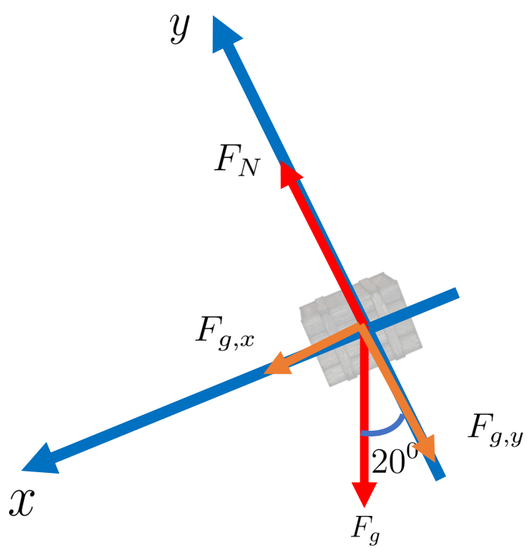
$$F_N = F_{g,y}$$

$$F_N = F_g \cdot cos(20^0)$$

$$F_N = m \cdot g \cdot cos(20^0)$$

$$F_N = 11.0\ kg \cdot 9.81\ \frac{m}{s^2} \cdot cos(20^0)$$

$$\boxed{F_N = 101.\ N}$$



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# B) Find the acceleration of the crate.

Newton's 2nd Law

X axis

$$\sum F_x = m\ a_x$$

$$F_{g,x} = m \cdot a_x$$

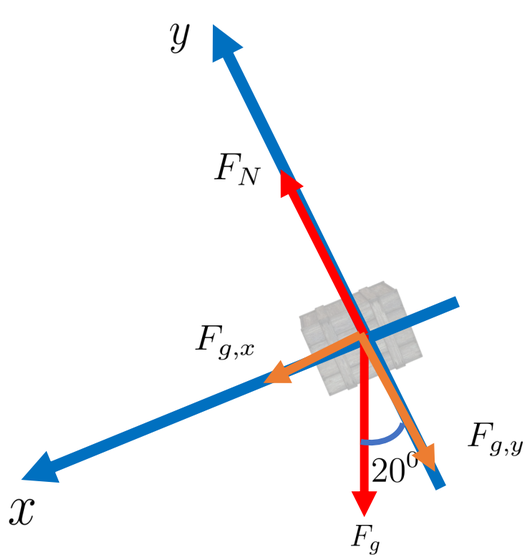
$$\cancel{m} \cdot g \cdot sin(20^0) = \cancel{m} \cdot a_x$$

$$g \cdot sin(20^0) = a_x$$

$$a_x = g \cdot sin(20^0)$$

$$a_x = 9.81\frac{m}{s^2} \cdot sin(20^0)$$

$$\boxed{a_x = 3.35\frac{m}{s^2}}$$



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# C) Find the final velocity of the crate at the end of the ramp.

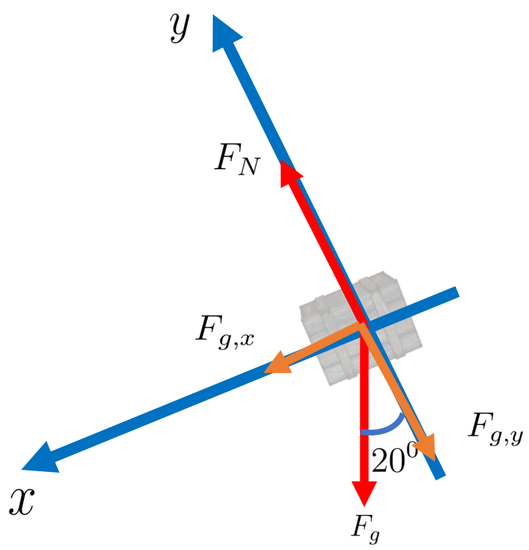
$$a_x = 3.35\frac{m}{s^2} \qquad v_i = 0 \qquad \Delta x = 2.50\ m$$

$$v_f^2 = v_i^2 + 2 \cdot a_x \cdot \Delta x$$

$$v_f = \sqrt{v_i^2 + 2 \cdot a_x \cdot \Delta x}$$

$$v_f = \sqrt{2 \cdot 3.35\ \frac{m}{s^2} \cdot 2.50\ m}$$

$$\boxed{v_f = 4.09\ \frac{m}{s}}$$



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