Physics 114 - Worksheet
for lecture B6 on position, velocity, and acceleration

1. My wife and I moved into our house last November, and we’re still unpacking. A box of mass 12.5 kg sits on a floor. I attached a rope to the box, as shown below, and my wife is pulling with a force of 45 N on the rope. As a result, the box moves at a constant velocity. What is the coefficient of kinetic friction between the box and the floor?

![Box and rope diagram]

\[ m = 12.5 \text{ kg} \]

\[ \theta = 20^\circ \]

Hint:
1. Draw a free-body diagram
2. Start with \( N \) in both directions
3. Use the Coulomb model of friction

See class notes...

2. The same box is placed on a ramp I made of plywood to cover our basement steps. The coefficient of kinetic friction between the box and plywood is 0.35, and the coefficient of static friction is 0.68. The ramp angle is 35° from the horizontal. Find the minimum ramp angle needed if the box is to start sliding down, from rest.

This is a poorly written question – sorry for the confusion!
Let’s proceed by ignoring the 35° specified, and answer the question for minimum ramp angle...

First, the minimum ramp angle will be that which allows the box to slide at constant velocity. Therefore, we’ll use \( a = 0 \).

Then: \[ \sum F_x = mg \sin \theta - f = 0 \quad \sum F_y = N - mg \cos \theta = 0 \]

We substitute \( f = \mu N \), then use \( N \) from the \( y \) equation.
(after algebra, I got:) \[ mg \sin \theta - \mu mg \cos \theta = 0 \]
Solve for \( \mu \).
3. (E43) Two blocks with masses \( m_1 = 3 \text{ kg} \) and \( m_2 = 5 \text{ kg} \) are connected by a light rope and slide on a frictionless surface as in the figure. A force \( F_o = 10 \text{ N} \) acts on the \( m_2 \) at \( 20^\circ \) to the horizontal. Find the acceleration of the system and the tension in the rope.

\[
\sum F_x = T - m_1 g \sin 30 = m_1 a \\
\sum F_y = F_o \cos 20 - T = m_2 a \\
\text{Solve this for } T, \text{ then plug into the first equation to solve for acceleration.}
\]

4. Now if there is friction \( (\mu_k = 0.3) \) between \( m_1 \) and the surface it is on, how much force is required \( (F_o) \) to pull both masses with constant velocity? Let the surface with \( m_2 \) remain frictionless.

**Modify the free body diagram for \( m_1 \), as shown:**

Then the equation needs to include friction too.

\[
\sum F_x = T - m_1 g \sin 30 - f = m_1 a \\
or \quad T - m_1 g \sin 30 - \mu N = m_1 a
\]

Now we need the normal force, so we need another equation.

\[
\sum F_y = N - m_1 g \cos 30 = m_1 a = 0 \\
\text{so then} \quad N = m_1 g \cos 30
\]

\[
T - m_1 g \sin 30 - \mu m_1 g \cos 30 = m_1 a
\]

Now we can substitute \( T \) from the other mass’ equation, and proceed to find acceleration.