- select a region of the graph after release and before crash and that is relatively linear.
- Choose "Linear Fit". The acceleration is the slope of the graph

  acceleration of cart+fan = $0.212\ m/s^2$
- Copy this number to the appropriate cell of the table.

3. Place the mass bar on the cart, under the fan, and again measure the acceleration, as before, with the additional mass

   acceleration of cart+fan+bar $0.136\ m/s^2$
   - Copy this number to the appropriate cell of the table.
4. Calculate the mass of the cart+fan in terms of the standard bar mass and enter the mass into the mass cell in the first row.

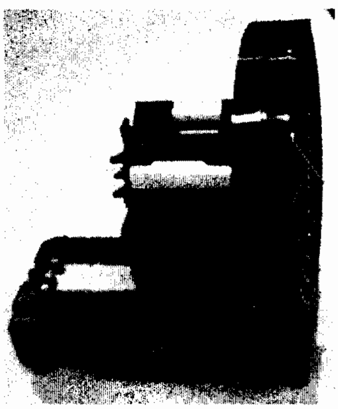
   Use the relationship $m_1/m_2 = a_2/a_1$. In this way we are using inertia as a way of measuring mass.

Comment: Physicists call the quantity you have just calculated--the ratio of combined (net) force on an object to its acceleration--the *inertial mass* of the object.

$$F_{net} = (m_{cf} + m_b)\, a_{cfb} = m_{cf}\, a_{cf}$$

$$m_{cf}\,(a_{cfb} - a_{cf}) = -m_b\, a_{cfb}$$

$$\frac{m_{cf}}{m_b} = \frac{a_{cfb}}{a_{cf} - a_{cfb}} = \frac{0.136\ m/s^2}{0.212 - 0.136\ m/s^2} = 1.79$$



mass of cart+fan = 1.79 bars

5. Assume that the bar mass is calibrated to be exactly 0.250 kg. Determine the mass of the cart+fan in kg.

$$1.79 \text{ bars} \times \frac{0.250 \text{ kg}}{\text{bar}} = 0.45 \text{ kg}$$

mass of cart+fan = 0.45 kg

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Prediction 3-1: Suppose that you place another standard bar on the cart, and accelerate it *with the same applied force*. Predict the acceleration and enter the predicted value after the "p:" in the table.

$F_{net} = m_{cf} a_{cf} = (m_{cf} + 2m_b)\, a.$

$a = \dfrac{m_{cf} a_{cf}}{m_{cf} + 2m_b} = \dfrac{1.49 \text{ bars}}{3.49 \text{ bars}} (0.212 \, m/s^2) = 0.10 \, m/s^2$ //

6. Test your prediction. Place another bar on the cart (borrowing one from a neighbour if necessary) and measure the acceleration. Enter the measured value in the table after "m:" and compare the value with your prediction.

measured a: $0.096 \, m/s^2$

this is close to predicted value.

Question 1-1: Did the acceleration agree with your prediction? If it's different, is it *significantly* different? (That is, considering the accuracy of your measurement, is any difference between the predicted value and the measured value real and reproducible?)

Yes it agrees.

Explain. frictional effects are greater w/ larger masses

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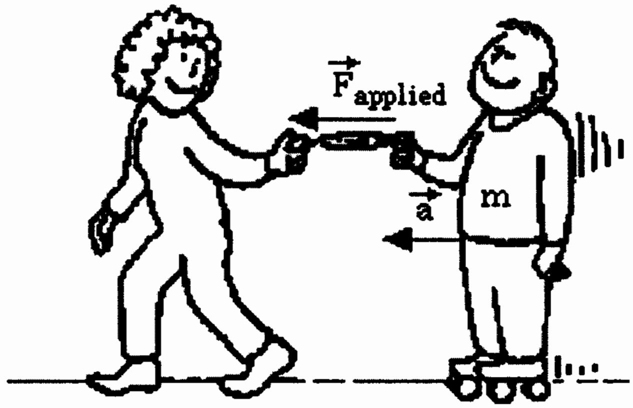
Question 2-5b: An object of mass 39 kg is observed to accelerate with an acceleration of 2.0 m/s/s. If friction is negligible, what is the force applied to the object in N? Show your calculation.

$F_{net} = ma = (39\,kg)(2.0\,m/s^2) = 78\,N$

Comment: The main purpose of this unit has been to explore the relationship between the forces on an object, the object's mass, and its acceleration. You have been trying to develop *Newton's First and Second Laws of Motion* for one-dimensional situations in which all forces lie in a positive or negative direction along the same line.



Activity 2-3: Newton's Laws in Your Own Words

Question 2-6: Express Newton's First Law (the one about constant velocity) in terms of the *combined (net) force* applied to an object in your own words clearly and precisely.

If the net force on an object is zero, it moves at constant velocity.

Question 2-7: Express Newton's First Law in equations in terms of the acceleration vector, the *combined (net)* force vector applied to an object, and its mass.

If $\Sigma \mathbf{F} = 0$ then $\mathbf{a} = 0$ and $\mathbf{v} =$ constant

Question 2-8: Express Newton's Second Law (the one relating force, mass, and acceleration) in terms of the *combined (net) force* applied to an object in your own words clearly and precisely.

The net force on an object is equal to its mass times its acceleration.

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Question 2-9: Express Newton's Second Law in equations in terms of the acceleration vector, the *combined (net) force* vector applied to an object, and its mass.

If $\Sigma \mathbf{F} \neq 0$ then $\mathbf{a} = \frac{\Sigma \vec{F}}{m}$

Comment: The use of the equal sign does not signify that an acceleration is the same as or equivalent to a force divided by a mass, but instead it spells out a procedure for calculating the magnitude and direction of the acceleration of a mass while it is experiencing a net force. What we assume when we subscribe to Newton's Second Law is that a net force on a mass *causes* an acceleration of that mass.

Beware, the equal sign has several *different meanings* in text books and even in these labs. In order to reduce confusion a few of the meanings of and symbols used for the "equal" sign are summarized below:

- $=$ • the same as (e.g., $2+2=4$)
- $=$ • also means equivalent to (e.g., four quarters is equivalent in buying power to one dollar)
- $=$ • can be calculated by (e.g., in physics for a body undergoing constant acceleration $v = v_0 + at$)
- $=$ • is replaced as (e.g., in a computer program $x = x+1$ means replace x with the value $x+1$)
- $\approx, \sim$ • is approximately the same as or equivalent to
- $\equiv$ • is defined as (e.g., $v_{avg} \equiv (x_2 - x_1)/(t_2 - t_1)$)

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