Cart, Bricks and Bands

A group of physics students conducted an experiment to determine the acceleration-mass-force relationship. Large rubber bands were connected to carts and stretched to a length of 20 cm. Students then pulled the carts along, being careful to keep the rubber bands stretched to 20 cm during the trial. **Figure 1** includes a diagram of the cart and rubber band. The force was changed by adding additional rubber bands. Doubling the number of rubber bands has the effect of doubling the force. Bricks were upon the carts in order to vary the mass of the carts. Since the bricks had the same mass as the cart, adding one brick to the cart would double the mass of the *object*. Adding two bricks to the cart would triple the mass of the *object*. To determine the acceleration of the carts, an apparatus known as a *ticker tape timer* was used. A long piece of narrow paper *tape* was attached to the carts. The paper tape was pulled through the timer. As the paper tape passed through the timer, ticks (small dots) were placed on the tape every 0.10 seconds. Distance measurements between several consecutive ticks were used to determine the acceleration. **Figure 2** shows the appearance of the ticks on the paper tape.

Figure 1

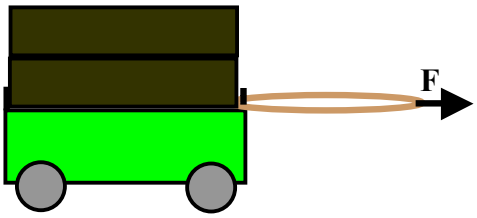


Figure 2

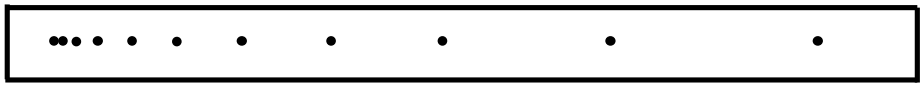


Table 1 and **Table 2** show the results. Use the data to answer the next several questions.

Table 1: Varying Force (constant mass: cart with 1 brick)		
Trial	**# of Bands**	**Accel'n**
1	1	0.24 m/s^2
2	2	0.51 m/s^2
3	3	0.73 m/s^2
4	4	1.00 m/s^2

Table 2: Varying Mass (constant force: 2 bands, 20 cm stretch)		
Trial	**Mass**	**Accel'n**
5	cart (no bricks)	0.99 m/s^2
6	cart with 1 brick	0.50 m/s^2
7	cart with 2 bricks	0.32 m/s^2
8	cart with 3 bricks	0.25 m/s^2

Questions:

1. Which one of the following changes would increase the amount of mass?
   a. Increase the number of bricks resting upon the cart.
   b. Increase the number of bands that are used to pull the cart.
   c. Decrease the number of bands that are used to pull the cart.
   d. Use a cart that is identical in every way, except for the color that it is painted.

2. Which of the following conclusions are specifically supported by the data in **Table 1**?
   a. A constant mass causes the acceleration value to increase.
   b. An increase in the number of bricks causes the acceleration to decrease.
   c. An increase in the length of the rubber band causes the acceleration to increase.
   d. An increase in the number of rubber bands causes an increase in the acceleration.

3. Which statement describes the effect of a doubling of force upon the acceleration of a cart of constant mass?
   a. Doubling the force will cause the acceleration to be twice the original value.
   b. Doubling the force will cause the acceleration to be one-half the original value.
   c. Doubling the force will cause the acceleration to be four times the original value.
   d. Doubling the force will cause the acceleration to be one-fourth the original value.

4. Which two trials demonstrate the effect of a doubling of force upon the acceleration of a cart of constant mass?
   a. Trials 2 and 4
   b. Trials 2 and 6
   c. Trials 4 and 7
   d. Trials 6 and 7

5. What acceleration results when 2 rubber bands stretched to 20 cm are used pull a cart with one brick?
   a. About 0.25 m/s^2
   b. About 0.50 m/s^2
   c. About 0.75 m/s^2
   d. About 1.00 m/s^2

6. What acceleration results when four rubber bands stretched to 20 cm is used pull a cart with one brick?
   a. About 0.25 m/s^2
   b. About 0.50 m/s^2
   c. About 0.75 m/s^2
   d. About 1.00 m/s^2

7. Which of the following conclusions are supported by the data in **Table 2**?
   a. Adding bricks to a cart has no affect upon the cart's acceleration.
   b. Increasing the mass of an object causes a decrease in its acceleration.
   c. An increase in the number of rubber bands causes an increase in the acceleration.
   d. The more mass that an object has, the more acceleration that it will acquire when pushed.

8. What acceleration results when 2 rubber bands stretched to 20 cm are used to pull a cart with three bricks?
   a. About 0.25 m/s^2
   b. About 0.33 m/s^2
   c. About 0.50 m/s^2
   d. About 1.00 m/s^2

9. Consider the following conditions for a group of experimental trials:

Conditions	Number of Bands used to Pull Cart	Number of Bricks on Top of Cart
A	2	3
B	1	1
C	3	1
D	2	2

Which conditions would result in the greatest acceleration?

a. Conditions A
b. Conditions B
c. Conditions C
d. Conditions D

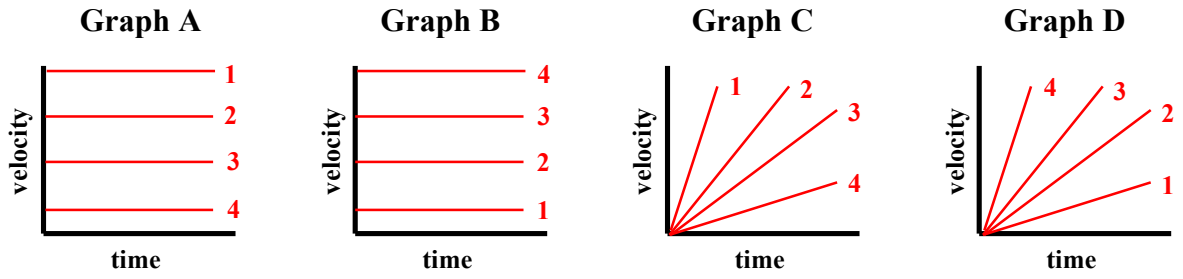
10. Predict the acceleration that would occur if four rubber bands were used to pull a cart loaded with two bricks.

a. Approximately 0.16 m/s^2
b. Approximately 0.50 m/s^2
c. Approximately 0.64 m/s^2
d. Approximately 1.00 m/s^2

11. Which proportionality below summarizes the relationship among variables in trials 5-8? (NOTE: **a** represents acceleration; **m** represents mass; **F** represents force; and the $\propto$ is the proportional symbol.)

a. $\mathbf{a} \propto \mathbf{m}$
b. $\mathbf{a} \propto \mathbf{F}$
c. $\mathbf{a} \propto \frac{\mathbf{1}}{\mathbf{m}}$
d. $\mathbf{a} \propto \frac{\mathbf{1}}{\mathbf{F}}$

12. Acceleration is the rate at which an object's velocity changes; it is often represented by the slope of a velocity-time graph. Which one of the velocity-time graphs accurately represents the data from trials 1-4? The trial number is listed next to the line.



13. A student determined that stretching one rubber band to a length of 36 cm produced the same amount of force as stretching two rubber bands to 20 cm. What acceleration could be predicted when one rubber band stretched to 36 cm was used to pull a cart with two bricks placed upon it?

a. Approximately 0.16 m/s^2
b. Approximately 0.32 m/s^2
c. Approximately 0.50 m/s^2
d. Approximately 0.60 m/s^2