

Physical Science 101  
 Newton's 2nd Law Virtual Lab

Name \_\_\_\_\_

Partner's Name \_\_\_\_\_

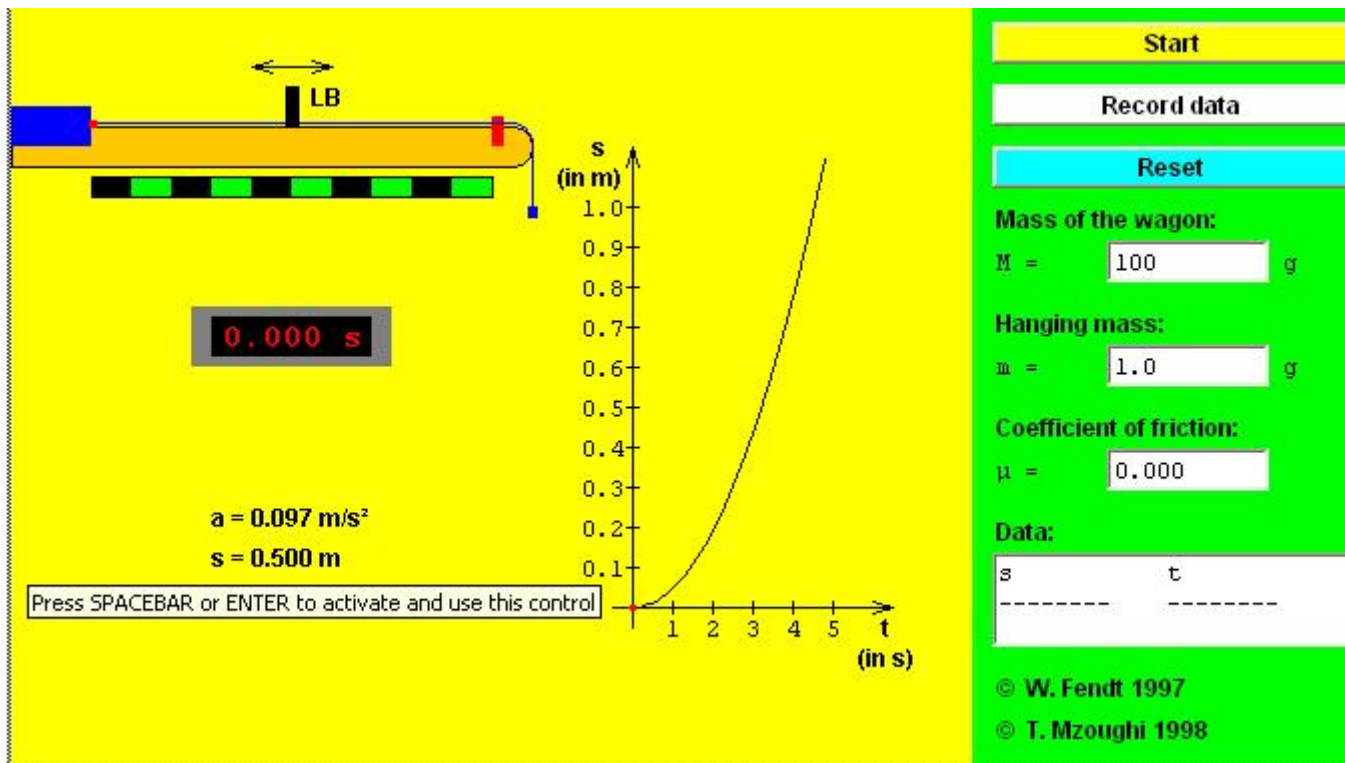
**Newton's Second Law:  $F_{net} = M_{sys} a$**

**The net Force acting on a system equals the product of the system's mass and acceleration.**

**Purpose**

To explore and understand Newton's 2nd law of motion, which relates the net force applied to an object to the objects mass and acceleration.

URL: <http://www.walter-fendt.de/ph11e/n2law.htm>



**Part A: Purpose:** To study **how acceleration is related to force** when the mass of a system is kept constant.

Design an experiment that will test how acceleration is related to force when the **system mass is held constant**. For this experiment the system mass is the total of wagon plus hanger mass. To increase the force (hanger weight) while keeping the system mass constant you must remove mass from the wagon and add an equal amount to the hanger so that the total wagon plus hanger mass stays fixed. Record your results in the following table.

Hanger mass g						
Wagon mass, g						
System mass, g						
Accel, m/s <sup>2</sup>						

By what factor does the acceleration change when you double the force?

Triple the force?

In the experimental design the acceleration was calculated by using the time and distance using,

$$s = \frac{a}{2} t^2$$

For two of your measurements above check to see if the formula below ( $a = \frac{F_{net}}{M_{sys}}$ ) gives the same results. Clearly show this comparison below. Remember in this experiment  $\mu=0.0$  so you can ignore the second term in the numerator.

$$a = \frac{mg - \mu Mg}{M + m}$$

- a ... acceleration
- m ... hanging mass
- g ... gravitational acceleration
- $\mu$  ... coefficient of friction
- M ... mass of the wagon

Comparison:

**Part B:**

**Purpose:** To study how the **acceleration is affected by the mass** when *the force is kept constant*. Repeat the above experiment except this time use a **constant hanger mass** but change the system mass by changing the wagon's mass. Fill in the table below.

Hanger mass g						
Wagon mass, g						
System mass, g						
Acceleration, g						

By what factor does the acceleration change when you double the system mass?

Triple the mass?

**Part C.**

**Purpose:** To explore friction.

Find the minimum hanger mass required to just move the system when the mass of the wagon is 100 g and the coefficient of friction  $\mu$  between wagon and table is 0.20? Find this minimum mass to the nearest 0.10 g.

Min. Hanger mass, g				
Wagon mass, g	100	100	100	100
$\mu$	0.20	0.40	0.60	0.80

The friction force opposing the motion is that maximum hanger force (weight) that will not cause acceleration. For each of the above what is the friction force? Remember that the hanger weight is the mass times gravity. For example, if we assume that  $g=10.0 \text{ m/s}^2$  then a mass of 10.0 g (0.010 kg) is a force of  $mg=0.010 \text{ kg} (10.0 \text{ m/s}^2)=0.1 \text{ N}$ .

Friction Force, N				
Wagon mass, g	100	100	100	100
$\mu$	0.20	0.40	0.60	0.80

What is the acceleration of the system for  $\mu=0.50$  , a hanger mass  $m=100$  g, and Wagon mass  $M=100$  g? (run this simulation)

How does the simulated acceleration compare to that calculated using Newton's second Law?

$$a = \frac{mg - \mu Mg}{M + m}$$

**Questions.** Don't forget your units.

1. How much net force is required to give a 20.0 kg car an acceleration of 4.0 m/s<sup>2</sup>?
2. What is the mass of a girl who accelerates at a rate of 8.0 m/s<sup>2</sup> when a net force of 56.0 N acts on her?
3. What net force is required to accelerate a 0.5 kg ball from rest to a speed of 30.0 m/s in 0.5 sec? (Hint: first find **a** using  $a=\Delta V/t$ )
4. What is the acceleration of a 30.0 kg boy when a net force of 60 N acts on him in the downward direction?
5. What is the weight of a 30.0 kg boy?
6. If the boy in the above two questions is falling through the air in a parachute, what is the upward force that the parachute exerts on the boy? Hint: the net force is 60 N down but the boy weighs 300 N. How big must the air resistance force be to cancel all but 60 N of the boy's weight?