

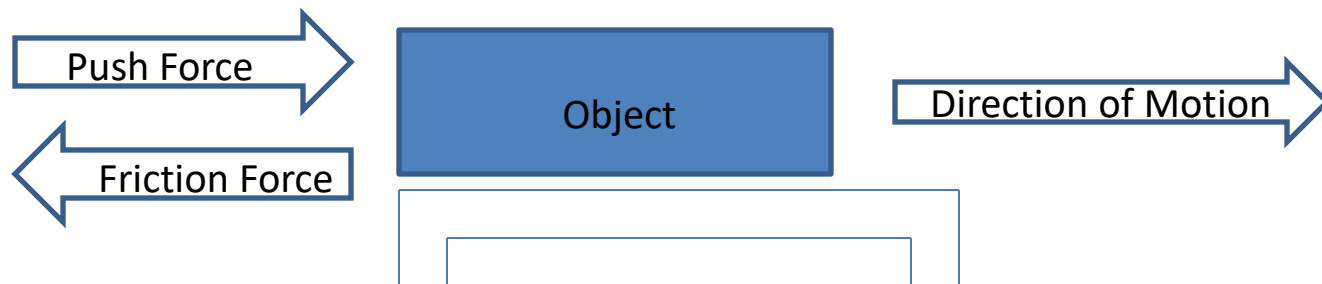


# Friction

Memphis Light, Gas, and Water

# What is friction?

- A force that is a response to an object sliding or rolling along a surface
- The force that causes a moving object to slow down when it is touching another surface



# Engineer's Definition of Friction

smoothness

stickiness

force pressing objects together

$$f = \mu * N$$

frictional force

coefficient of friction  
depends on the material

normal force

The diagram illustrates the equation for friction,  $f = \mu * N$ . The variable  $f$  is labeled as 'frictional force'. The Greek letter  $\mu$  is labeled as 'coefficient of friction' and 'depends on the material', with a note that it is determined by 'smoothness' and 'stickiness'. The variable  $N$  is labeled as 'normal force' and is described as the 'force pressing objects together'.



What happens to friction if you increase the normal force? (N)

1. Put your hands together and rub them gently.

Do your hands feel hot?

2. Put your hands together and rub them hard.

Do your hands feel the same or hotter?

Pushing you hands together harder **increased the normal force** that in turn **increased the friction**.

The heat you feel is the **conversion of kinetic energy** (motion) from rubbing **to heat energy**.



What happens to friction if you change the material? ( $\mu$ )

1. Place a piece of paper between your hands.
2. Rub them together again real hard.

Do your hands feel as hot as they did without the paper?

Putting the paper between your hands changed the material, i.e. it changed the  $\mu$ .

The smaller the  $\mu$ , the smoother the material, the less friction created and the less energy converted to heat.



How does friction apply to your solar car?

1. Any friction acting on the car will slow it down. **Energy from your solar panel will be wasted overcoming friction** instead of propelling it forward.
2. From the first demo we learned that:  
the larger the value for  $N$ , the contact force,  
the larger the value for  $f$ , the friction force.



How does friction apply to your solar car?

3. From the second demo we learned that:  
the smaller the value for  $\mu$ , very smooth, the smaller the value for  $f$ , the friction force.

If  $\mu$  is too high, i.e. rough, the car won't move.

If  $\mu$  is too low, i.e. slick, the wheels will spin out.

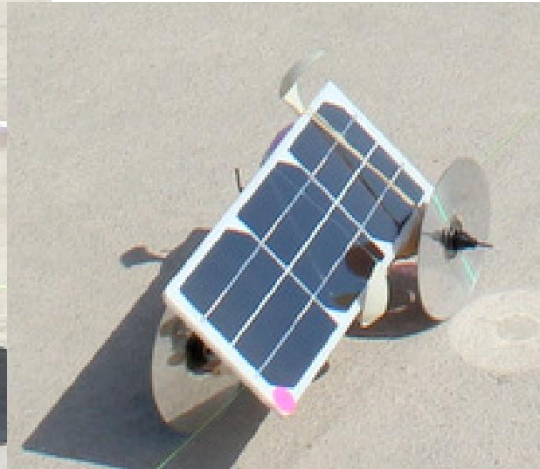


# **The MLGW** **A-Blazing Race**

*A Model Solar  
Car Race*

How does friction apply to your solar car?

Looking for the right amount of friction

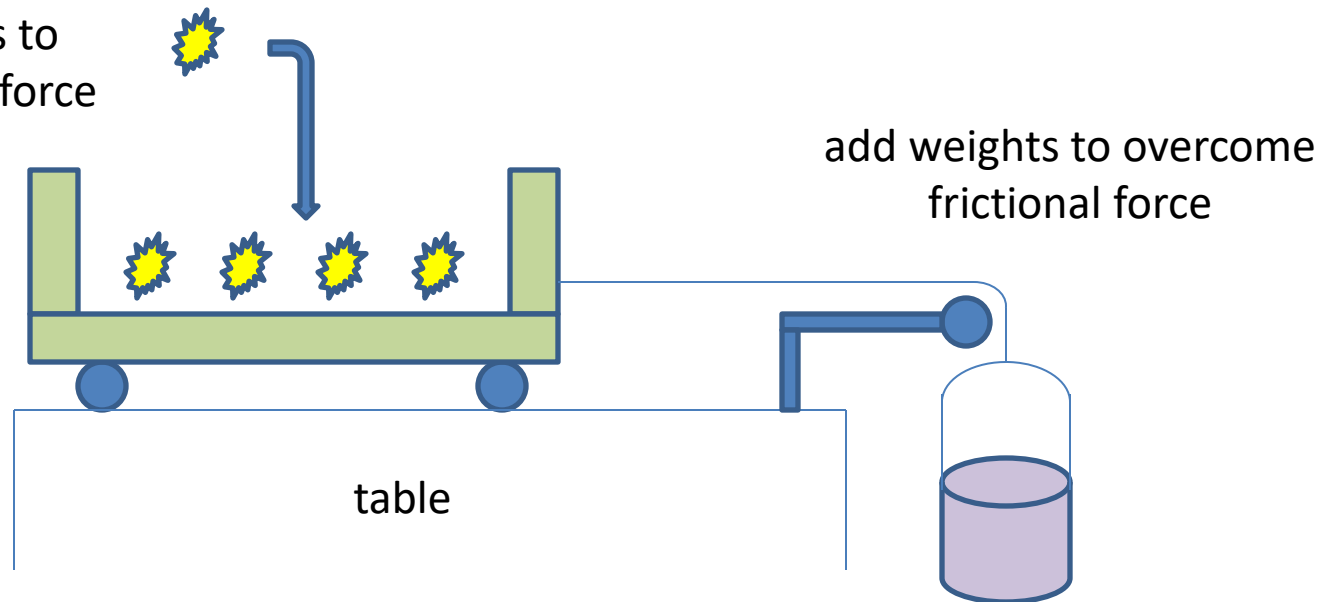




# Effect of Weight

Let's examine the effect of increasing the weight of the car (normal force), on the force needed to set it in motion (overcome friction).

adding weights to  
increase normal force





# Effect of Weight

## Observation

As the weight of the car increased, (increased normal force) more force was needed to set the car in motion (overcome friction).

## Conclusion

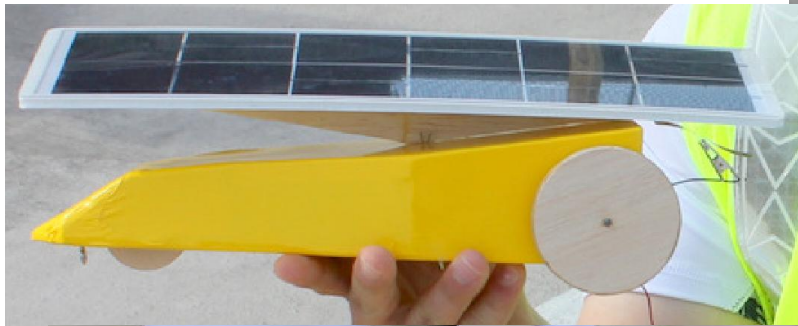
The heavier the car the more energy it takes to move it, i.e. the slower it will go.

# The MLGW A-Blazing Race

A Model Solar  
Car Race

- Lightweight  
Materials

## Effect of Weight





# Effect of the Axle

Does the design of the axle have an effect on the friction?

Option A: the wheel is fixed to the axle and the whole axle rotates with the wheel. (look at the material for the axle and the support for the axle)

Option B: the axle is fixed to the car and only the wheel rotates on the axle. (look at the material for the axle and the wheel)



# The MLGW A-Blazing Race

A Model Solar  
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## Effect of Axle

- Where is the Friction?

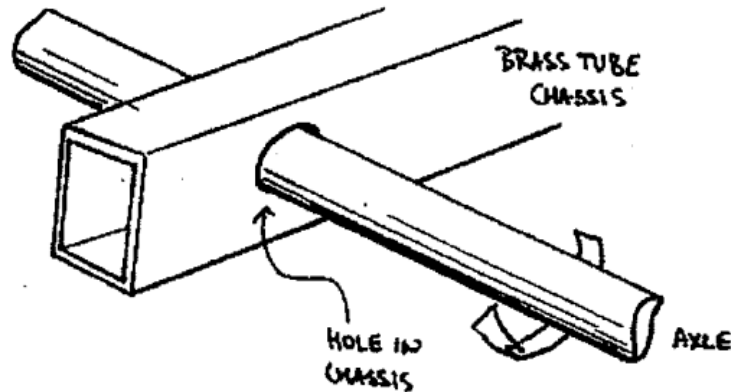
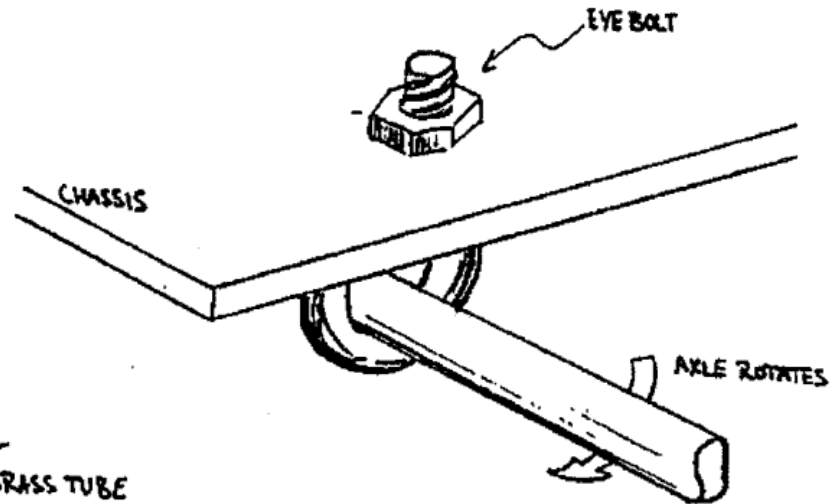
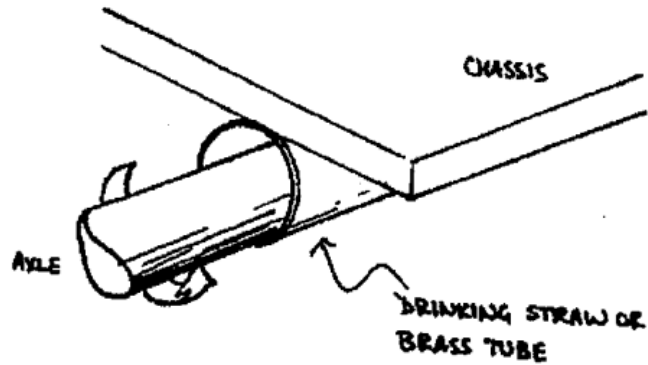


# The MLGW A-Blazing Race

A Model Solar  
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## Effect of the Axle





## Other Things to Consider

1. The location of the wheels and axles along the length of the car.  
Example: front wheel drive vs rear wheel drive  
(Reverse the leads on the motor to run your car backward. Which way is faster?)
2. In designing the drive mechanism, look at moving parts. Friction between these parts may reduce the energy transmitted.



# The MLGW A-Blazing Race

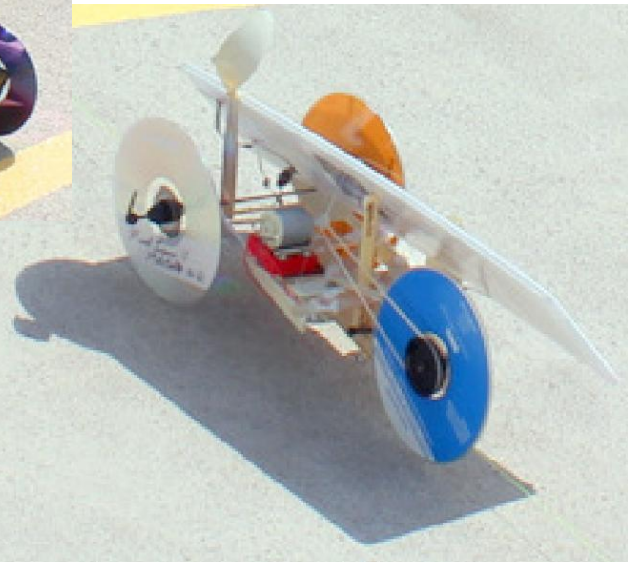
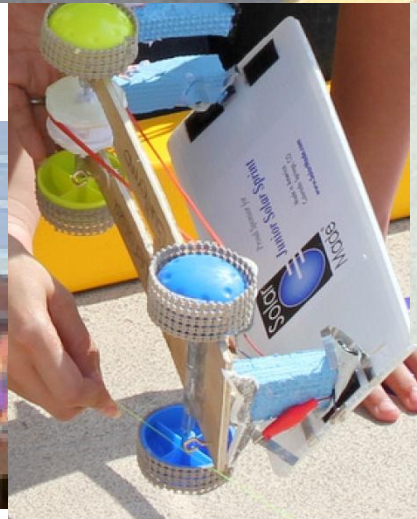
A Model Solar  
Car Race

## Other Things to Consider

- Location of Axle, Drive Wheel

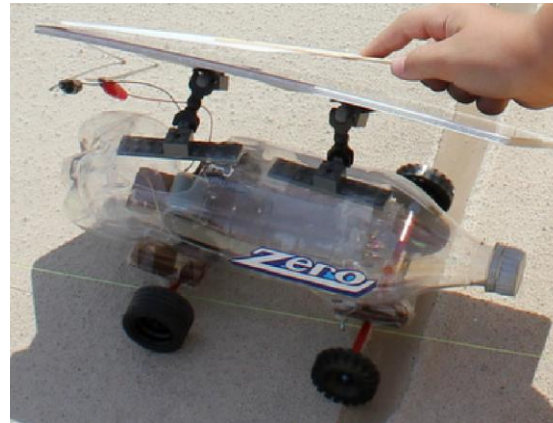
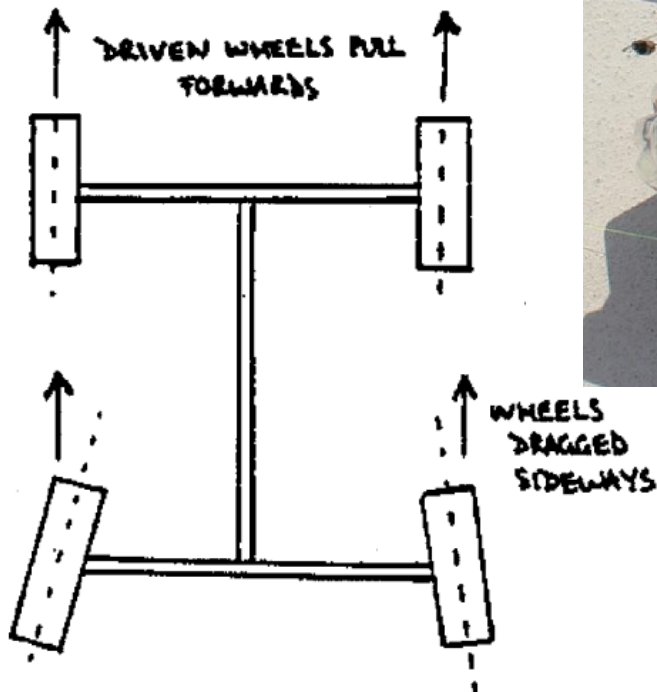


- Drive Mechanism



## Other Things to Consider

3. Take care that the wheels are aligned properly. A tilted wheel will drag rather than roll. Dragging will increase the friction.





Have Fun Building Your Car!

Be Creative

See you in February!