Team Name / (Students):_____

Solar Racing (Student Handout)

(The Design, Construction, and Evaluation of a Solar-Powered Car)

PART 1 (DESIGN YOUR OWN SOLAR-POWERED VEHICLE)

1) It is time for you to become an engineer. You have the knowledge to build your very own solar powered car! You and a partner(s) will be supplied with a motor, wheels, axles, and a solar cell. It is your job to design the car.

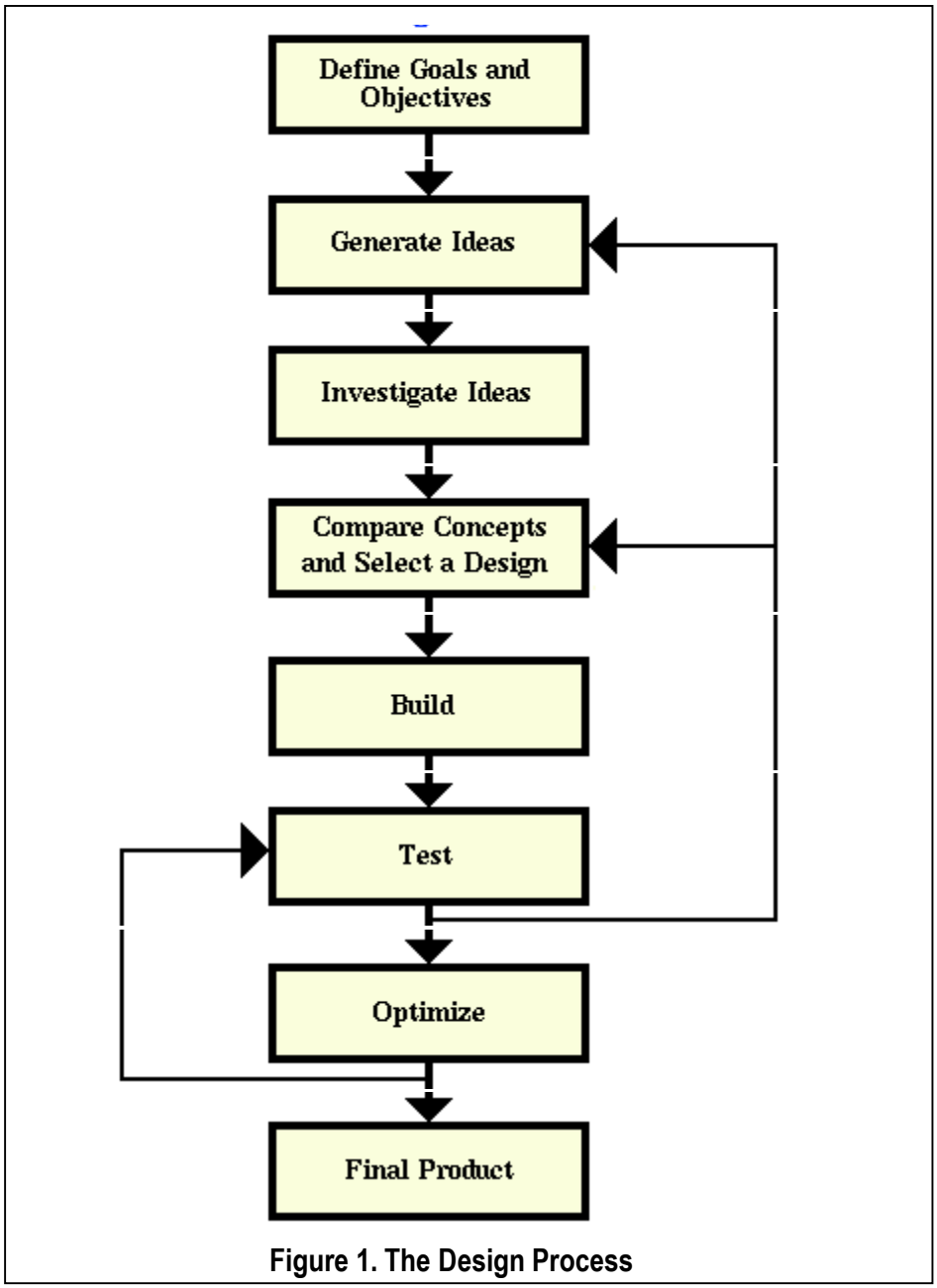

Figure 1. The Design Process

a) Talk with your partner and answer the following questions. What are some of the features you think your car should have to maximize the energy produced by the solar panel? What kind of materials should be used for the body?

Record what you think in the box provided.

Brainstorming Session

What features should our car have? What materials should we use to make it?

b) Draw a diagram of your car's design below. Please use a separate page if you need more room. Think about strategic placement of the various necessary components in order to create the fastest car possible. Think about how you will go about securing the wheels and axles, as well as the motor and the solar cell.

Car Design #1:

Front View:

Top View:

Side View:

PART 2: IMPORTANT ASPECTS OF THE CAR'S DESIGN

1) In this section you will be working through a series of calculations to make choices about your car's gear ratio, wheel size and transmission. Use the text examples and figures to help you work through the calculations.

GEAR RATIO[3]:

The complete requirements for gearing ratios include the wheel size since it affects the speed versus force conditions. The two transmission ratios and wheel size combinations shown below will produce cars with similar performance in terms of acceleration and top speed.

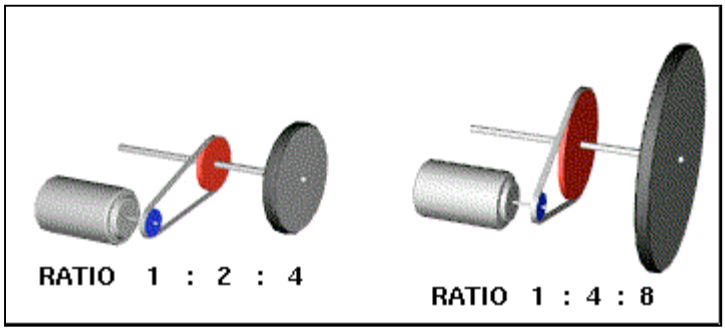

Figure 1: Transmission wheel combinations

The faster the axle rotates in the bearing the more friction and drag it will have. A large wheel will allow the axle to rotate more slowly (if the car is to go at the same speed), and will waste less power in the bearings. In nature, an analogy for wheel size would be leg length. Just as a horse and hamster will travel different distances if each takes one step per second, cars with large and small wheels will travel different distances with each wheel rotation.

If you already know your gear ratio:

If we have a set of pulleys or a couple of mating gears then we already have the gear ratio. Now we just need to find out what size drive wheel(s) we need to be competitive. Figure 2 shows how a pulley or gear system might look.

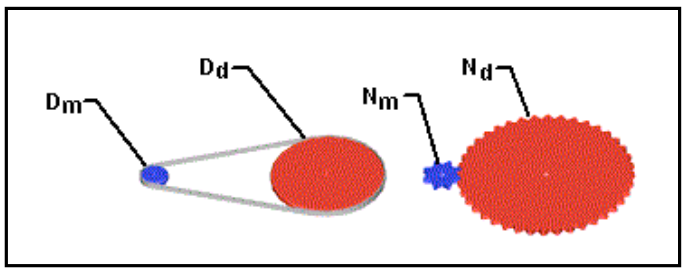

Figure 2: Pulley and Gear Systems

The variable **D** is the diameter of the pulley, and variable **N** is the number of teeth on the gear. The subscript **d** refers to the gear or pulley attached to the drive axle and the subscript **m** refers to gear or pulley attached to the motor.

For sample purposes we have supplied values for these - use your own values to do the calculations on your own transmission.

The variables for a Pulley System

D_m = **1.25** cm D_d = **0.25** cm

The variables for a Gear System

N_m = **40** teeth N_d = **8** teeth

The variables for a YOUR System

[___]$_m$ = [_____] [___]$_d$ = [_____]

Step 1: Determine the gear ratio.

For a Pulley System the gear ratio is

R = D_m / D_d or **R** =**1.25** cm / **0.25** cm or **R** =**5**

For a Gear System the gear ratio is

R = N_m / N_d or **R** =**40** / **8** or **R** =**5**

For YOUR System the gear ratio is

R = [__]$_m$ / [__]$_d$ or **R** =[___] / [___] or **R** =[___]

Step 2: Find out the speed of the wheel in rpm.

For a Pulley or Gear System wheel speed is

w_d = w_m / **R** or w_d = **8300** rpm (revolutions per second) / **5** or w_d = **1660** rpm

For YOUR System wheel speed is

w_d = w_m / **R** or w_d = [____] rpm / [____] or w_d = [_____] rpm

Step 3: Find out wheel speed in revolutions per second.

For a Pulley or Gear System wheel speed in rps is

$w_d = w_d$ / **60** spm or w_d = **1660** rpm / **60** spm (seconds per minute) or w_d = **27.6** rps

For YOUR System wheel speed in rps is

$w_d = w_d$ / **60** spm or w_d = **[____]** rpm / **60** spm or w_d = **[____]** rpm

Step 4: Calculate the wheel circumference.

To determine the wheel diameter, we first need to know the circumference of the wheel (the distance the car will travel each time the wheel turns one full revolution).

For a Pulley or Gear System the circumference is

C = **V** / w_d or **C** = **300** cmps / **27.6** rps or **C** = **11** cm

For YOUR System the circumference is

C = **V** / w_d or **C** = **[____]** cmps / **[____]** rps or **C** = **[___]** cm

Step 5: Determine the wheel diameter.

Now we can find out what diameter wheel, D_w we need. The wheel diameter is determined from the circumference.

For a Pulley or Gear System the diameter is

D_w = **C** / **pi** or D_w = **11** cm / **3.14** or D_w = **3.5** cm (1.4 in)

For YOUR System the diameter is

D_w = **C** / **pi** or D_w = **[___]** cm / **3.14** or D_w = **[____]** cm

Step 6: Check your calculations.

Now check to make sure the diameter of your wheel is bigger than the diameter of the drive gear. If it is, you're up and running. If it is not, you need to choose smaller pulleys or gears.

WHEEL SIZE

If we already have a wheel size we want to use, we must find a suitable gear ratio to drive it. For sample purposes we have supplied values for these--use your own values to do the calculations on your own transmission.

The variables for a Wheel

D_w = **8** cm (3.1 in)

The variables for a YOUR Wheel

D_w = **[_____]**

Step 1: Calculate the wheel circumference.

For a Pulley or Gear System wheel circumference is

C = D_w * **pi** or **C** = **8** cm * **3.14** or **C** = **25** cm

For YOUR System wheel circumference is

C = D_w * **pi** or **C** = **[___]** cm * **3.14** or **C** = **[____]** cm

Step 2: Find the wheel speed in revolutions per second.

For a Pulley or Gear System wheel speed in rps is

w_d = **V** / **C** or w_d = **300** cmps / **25** cm or w_d = **12** rps

For YOUR System wheel speed in rps is

w_d = **V** / **C** or w_d = **[____]** cmps / **[___]** cm or w_d = **[___]** rps

Step 3: Find the wheel speed in revolutions per minute.

For a Pulley or Gear System wheel speed in rpm is

w_d = **60** spm * w_d or w_d = **60** spm * **12** rps or w_d = **720** rpm

For YOUR System wheel speed in rpm is

w_d = **60** spm * w_d or w_d = **60** spm * **[___]** rps or w_d = **[_ __]** rpm

Step 4: Determine the gear ratio.

For a Pulley or Gear System the ratio is

R = w_m / w_d or **R** = **8300** rpm / **720** rpm or **R** = **11.5**

For YOUR System the ratio is

R = w_m / w_d or **R** = **[____]** rpm / **[____]** rpm or **R** = **[____]**

DESIGN A TRANSMISSION

Since the drive pulley or gear can be no larger than the drive wheel, we need to select a pulley or gear accordingly.

For a Pulley System we might select a drive pulley of 6 cm in diameter.

D_m = D_d / **R** or D_m = **6** cm / **11.5** or D_m = **.52** cm

For a Gear System we might select a drive gear of 69 teeth.

D_m = D_d / **R** or D_m = **69** teeth / **11.5** or D_m = **6** teeth

For YOUR System select a drive pulley or gear that is appropriate

D_m = D_d / **R** or D_m = **[_____]** / **[____]** or D_m = **[_____]**

WHAT ELSE IS IMPORTANT?

- Chassis: Brains and brawn apply here—your chassis needs to support the motor and your PV panel.
- Wheels & Bearings: Wheel size is as important a factor in the car's design as the transmission ratio; in fact, they are closely related. Try to calculate what distance your car travels per one revolution of the motor. The transmission ratio will tell you how many revolutions the wheel axles will turn per motor revolution, and the size of the wheels will tell what linear distance the car will travel per wheel revolution. (You have done this hard work in the Gear Ration Calculations part.)
- Body Shell & PV Panel: How are you going to direct your solar panel? Will you use reflectors? How light do you want your car to be?

PART 3: ALLOW YOUR CLASS DEVELOPMENT TEAM TO REVIEW YOUR DESIGN

1) An important part of the design process is comparing your design to others and select the most promising you decide is best. Your task in Part 3 is to share your final sketch or drawing of the car with your classmates. Some ideas you should consider when planning your 5 minute presentation are:

   - ✓ How are you going to present your information? (You may want to ask your teacher if you can make a transparency of your car design to use).

   - ✓ What components have you decided on for the following?

     a. Transmission

     b. Chassis

     c. Wheels & Bearings

     d. Body Shell & PV Array

   - ✓ What design considerations are important to your team? [Drag, Rolling Resistance, Drive Train, Car Weight, etc].

   - ✓ What materials will you use to build the body of the car?