

Freshman Engineering Clinic I
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Mechanical Engineering Module

Dynamics of the Soccer Robot

Background

Robots continue to become more commonplace in today's society and are an excellent example of an electro-mechanical device. Science fiction stories and movies depict sophisticated robots that will change our lives.

Today, robots are widely used in industrial applications, especially in manufacturing. They are often used to perform simple, repetitive tasks, such as painting automobiles or bolting parts of machines together. The intelligence of robots is continually improving and is the topic of much current research.

Over the course of the three weeks, we will use robots in our study of dynamic systems, materials, engineering drawing and computer programming.

Objectives

- Measure distance and time
- Calculate speed of the robot
- Learn about gears
- Calculate speed of the motor using gear ratios
- Have fun

Theory for Dynamics and Gears

SPEED

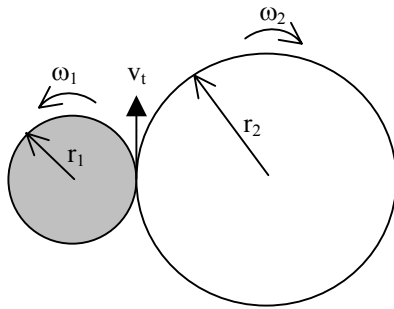
Average speed is a scalar quantity used to describe the distance traveled during some amount of time. Mathematically that is expressed as

$$v = d/t$$

where v is speed, d is distance traveled and t is time

GEARS AND GEAR TRAINS

When two gears are in mesh, the pitch circles roll without slip on one another. If the pitch radii are r_1 and r_2 and the angular velocities are ω_1 and ω_2 then the pitch line velocity is $v_t = |r_1\omega_1| = |r_2\omega_2|$



The relation between the radii and angular velocities is

$$\left| \frac{\omega_1}{\omega_2} \right| = \frac{r_2}{r_1}$$

If the pinion (gear 1) is driving gear 2, the speed of the driven gear is

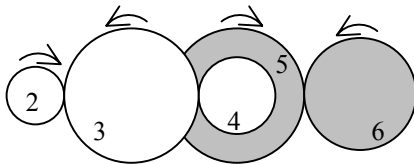
$$n_2 = \left| \frac{N_1}{N_2} n_1 \right| = \left| \frac{d_1}{d_2} n_1 \right|$$

where n = revolutions per minute (rev/min)

N = number of teeth

d = pitch diameter

This equation applies to any gear train no matter what types of gears (spur, helical, bevel or worm).



For a gear train of many gears, such as the five shown in the figure above (note that gears 4 and 5 are connected on the same shaft), the speed of gear six is

$$n_6 = -\frac{N_2}{N_3} \frac{N_3}{N_4} \frac{N_5}{N_6} n_2$$

The negative sign is due to the fact that the first (gear 2) and last (gear 6) rotate in opposite directions. Note that gear 3 is an idler; its number of teeth cancels in the equation and it only affects the direction of gear 6. Gears 2, 3 and 5 are drivers, and gears 3, 4, and 6 are driven. The gear train value, e , is

$$e = \frac{\text{product of driving tooth numbers}}{\text{product of driven tooth numbers}}$$

Thus

$$n_L = en_F$$

where n_L is the speed of the last gear and n_F is the speed of the first gear

Procedure:

1. Get together with your group members
2. Designate a leader, recorder, etc.
3. Run the robot to ensure that it works
4. Make a table of distance and time
5. Measure a distance to run the robot and record the time for the robot to travel that distance. Calculate the average speed of the robot over 5 trials.
6. Partially disassemble the robot body into the right and left halves so that the gear train is exposed
7. Draw a schematic diagram of the gears in the gear train
8. Number the gears. Be careful if 2 gears share the same axle.
9. Measure the diameters of the gears and count the number of teeth on each gear
10. Record in a table - the gear number, the diameter and number of teeth for each
11. Use the gear ratio formula to compare the speed of the axle to the speed of the motor (calculate e)
12. Reassemble the robot
13. Run the robot to be sure it is properly reassembled
14. HW as a supplement to your lab report - List 5 specific mechanical devices that use gears and where the gears are located (ex. In a mouse robot to transfer rotating motion of the motor to the wheels)

For next week

Turn in lab report and homework.