

Activity 1.1.5 Gears, Pulley Drives, and Sprockets Practice Problems

Introduction

You do not have to look far to see gears. You might not think of an object such as a computer as having a lot of moving parts, but the CD tray on your computer is likely controlled by gears. A traditional watch is full of gears. The watch has one source of power or input that must move multiple hands continuously and at different speeds. Some watches also keep track of the day of the month. This may be low-tech by today’s standards, but imagine the challenge of choosing just the right gears to keep a watch synchronized. In a watch the gears are used to manipulate rotational speed. Gears are also used in many applications to control torque and rotational direction.

Procedure

In this activity you will learn about gear ratios and how they affect speed and torque within a system.

Functions of Gears

* Gears change the speed of rotation.
* Gears change the direction of rotation.
* Gears change torque values.

Gear Ratios

|  |  |
| --- | --- |
| By joining together two or more gears of different sizes, both the speed and the torque are changed from the input gear to the output gear. The larger gear within a system will always move slower and have more torque than the smaller gear. Gear Ratio (GR) is a comparison between the driver gear, also called the input (connected to the power source), and the gear being driven, or the output. Below are four ways to determine the gear ratio in Figure 1. |  |

Method 1**:** The gear ratio can be determined by counting the number of teeth on each gear.The ratio is expressed by dividing the number of teeth on the output gear (nout)by the number of teeth on the input gear (nin).



Gear ratios are often expressed using a colon. In this example the ratiois 2:1 (pronounced two to one).The gear ratio of 2:1 indicates that the driver gear is half the size of the driven gear, and that the driver gear will make two revolutions for every one made by the driven gear.

Method 2: The gear ratio can be determined using the diameter of each gear.Assume that the diameter of gear A is 2.5 in. (din), and the diameter of gear B is 5 in. (dout).



Method 3: The gear ratio can be determined by recording and comparing the angular velocity or speed at which each gear is turning. The lower case Greek letter ωis used to represent angular velocity. A common way to measure angular velocity is using revolutions per minute (rpm). Assume that the rpm of the input gear is 446 rpm and the rpm of the output gear is223 rpm.



Method 4: The gear ratio can be determined by recording the torque at each gear. Divide the torque at the output gear (τout) by the torque at the inputgear (τint). A common way to measure torque is to usefoot pounds(ft·lb). Assume that the torque force at the driver gear is 4 ft·lb and the force at the driven wheel is 8 ft·lb of torque.



The above equations all solve for the gear ratio of the driver gear to the driven gear.Based upon these formulas, the following is true.



Solving for Speed and Torque

In most applications you will know the speed and torque provided by your driver or input gear. You will mesh another gear to achieve a specific output speed or output torque to accomplish a task.Below are some examples that illustrate this.

Example 1:A motor is driving anaxle with a6-in.-diameter drive gear. The speed of the motor is 20 rpm. A gear must be attached that increases the speed to 100 rpm. What size diameter should the attached gear be?





Example 2: A motor is driving an axle with a 30-tooth drive gear. You know that the maximum output torque of the motor is only 90 ft·lb. A gear must be attached that will increase the torque force to 300ft·lbin order to lift a heavy object. How many teeth should the attached gear have?





Gear Trains

|  |  |
| --- | --- |
| A gear train consists of two or more gears assembled in order to transfer energy from one axis to others. |  |

Idler Gears

|  |  |
| --- | --- |
| When two gears are meshed together, each will rotate in an opposite direction. If the desired rotation for two gears is the same, an idler gear is introduced. In Figure 3 the two outside gears will move at the same speed and direction and will have the same torque because of the idler gear between them. If they were attached without the idler gear, they would have matching speed and torque, yet would be rotating in opposite directions. |  |

Simple Gear Trains

|  |  |
| --- | --- |
| A simple gear train connects two or more gears in a row, each gear having its own axle. |  |

Procedure

Answer the following questions regarding gear, pulley, and sprocket systems. Each question requires proper illustration and annotation including labeling of forces, distances, direction, and unknown values. Illustrations should consist of basic topview assembly sketches rather than realistic pictorials.

All problem calculations should assume ideal conditions and no friction loss.

Gears

A simple gear train is composed of three gears. Gear A is the driver and has 8 teeth, gear B has 24 teeth, and gear C has 16 teeth.

1. Sketch and annotate the gear train described above.

|  |
| --- |
|  |

1. If the output is at C, what is the gear ratio?

|  |  |  |
| --- | --- | --- |
| Formula | Substitute / Solve | Final Answer |
|  |  |  |

1. If gear A rotates at 60 rpm, how fast is gear C rotating?

|  |  |  |
| --- | --- | --- |
| Formula | Substitute / Solve | Final Answer |
|  |  |  |

1. If the output of torque at gear C is 150 ft·lb, what is the input torque at gear A?

|  |  |  |
| --- | --- | --- |
| Formula | Substitute / Solve | Final Answer |
|  |  |  |

A compound gear train is composed of four gears: A, B, C, and D. Gear A has 10 teeth and is meshed with gear B. Gear B has 20 teeth and shares a shaft with gear C, which has 16 teeth. Gear C is meshed with gear D, the output gear. Power is supplied at gear A with 100 ft·lb of torque andis traveling at1,600 rpm.

1. Sketch and annotate the gear train described above.

|  |
| --- |
|  |

1. The necessary torque output for the system is 500 ft·lb. What should the gear ratio of the system be?

|  |  |  |
| --- | --- | --- |
| Formula | Substitute / Solve | Final Answer |
|  |  |  |

1. With a system torque output of 500ft·lb, how many teeth should gear D have?

|  |  |  |
| --- | --- | --- |
| Formula | Substitute / Solve | Final Answer |
|  |  |  |

Pulleys and Belts

In a pulley system, pulley A is moving at 1,500 rpmandhas a diameter of 15 in. Three pulleys, B,C, and D,all of different sizes, are attached to a single output axle. Speed and torque output are changed within the system by moving the drive belt between pulleys B, C, and D.

1. Sketch and annotate the drive train described above.

|  |
| --- |
|  |

1. A speed of 1,750 rpm is required when the drive belt is connected to pulley B. What is the diameter of pulley B?

|  |  |  |
| --- | --- | --- |
| Formula | Substitute / Solve | Final Answer |
|  |  |  |

1. A speed of 2,000 rpm is required when the drive belt is connected to pulley C. What is the diameter of pulley C?

|  |  |  |
| --- | --- | --- |
| Formula | Substitute / Solve | Final Answer |
|  |  |  |

1. A speed of 3,250 rpm is required when the drive belt is connected to pulley D. What is the diameter of pulley D?

|  |  |  |
| --- | --- | --- |
| Formula | Substitute / Solve | Final Answer |
|  |  |  |

Sprockets and Chains

An industrial overhead door has sprocket and chain system designed to reduce the force needed by an operator to open and close the door. The system consists of two individual systems that are connected through a live axle shaft. To operate the door, the operator pulls a continuous loop of chain over a fixed 22-tooth sprocket that is attached to a live axle shaft (system 1). A second 22-tooth sprocket is attached to the live axle shaft and uses a chain connected to a 48-tooth sprocket that is attached to a drum that drives the door.

1. Sketch and annotate the drive train described above.

|  |
| --- |
|  |

1. What is the overall system gear ratio?

|  |  |  |
| --- | --- | --- |
| Formula | Substitute / Solve | Final Answer |
|  |  |  |