

## Worksheet: Mobile Robots and Strength

Name: \_\_\_\_\_

Date: \_\_\_\_\_

1. Which of the following is not a measure of torque:
  - a. Foot-pound
  - b. Horsepower
  - c. Newton-meter
  - d. Joule
  
2. A belt and pulley system is just like a gear system except that:
  - a. The drive pulley and the driven pulley turn in the same direction
  - b. The gear ratio for a pulley system is the reverse of the gear ratio of a gear system
  - c. Gears operate because of friction, while pulleys operate because they mesh
  - d. An idler pulley must be included in each pulley system.
  
3. The larger the gear ratio of a gear or pulley system:
  - a. The greater the speed
  - b. The greater the power
  - c. The greater the torque
  - d. The less the power.
  
4. A belt and pulley system is used to protect the drive motor when:
  - a. The driven wheel could slip and the motor could turn too fast
  - b. The driven wheel is too big and the motor could turn too slow
  - c. The battery is running down
  - d. The driven wheel could get stuck and lock up the motor.
  
5. A radian is:
  - a.  $\pi/180^\circ$
  - b.  $180^\circ/\pi$
  - c.  $60^\circ$
  - d.  $90^\circ/\pi$

6. Which of the following are not a measure of Power:
  - a. Horsepower
  - b. Watt
  - c. Foot-pound
  - d. Foot-pound/second
  
7. Gearing down your robot to increase its torque will:
  - a. Slow the robot down
  - b. Speed the robot up
  - c. Increase its power
  - d. Decrease its power
  
8. The use of treads can increase a robot's useful power because:
  - a. The hubs that are used with the Lego treads spin freely on the axle
  - b. There is a lot more surface area in contact with the ground, providing much more traction than wheels with tires.
  - c. They will slip more freely than a tire, protecting the motor from locking up
  - d. They provide less friction with the ground, providing less torque to the drive wheels.
  
9. Belt and pulley systems transfer force by:
  - a. Speed
  - b. Rate of power
  - c. Friction
  - d. Heat
  
10. Compound pulley ratio:
  - a. Acts the same as compound gear ratio
  - b. Acts the same as an idler gear in a gear ratio
  - c. Acts the opposite as compound gear ratio
  - d. Has no direct equivalent to gear ratio.

## Solutions: Mobile Robots and Strength

1. b. Horsepower is not a measure of torque; it is a measure of Power. Remember that torque is equal to a force times a distance, so obviously foot-pounds and Newton-meters are correct. A joule is the measure of work in the MKS (Meter-Kilogram-Second) measurement system and is equal to approximately 0.738 foot-pounds.
2. a. In a system of gears, a gear turns in the opposite direction of its drive or driven gear due to the meshing of the teeth. In a belt and pulley system, the pulleys turn in the same direction because the movement of the belt is in the same direction across both pulleys.
3. c. The larger the gear ratio, the greater the torque. Gearing of a motor output is a trade-off between torque and speed. As speed goes up, torque goes down and as speed goes down, torque goes up. The Lego motors are constant speed, constant power motors. Gearing has no bearing on the power output of the motor.
4. d. In a system of gears, when the driven wheel gets stuck, it locks up the motor, even though it is still trying to turn. Putting power to the motor when it can't rotate causes heat to build up to the point where the motor insulation could melt and short out the motor. If the wheel is driven by a belt and pulley system, even when the wheel locks up, the motor will still turn, causing the belt to slip on the driven pulley. Over a long period of time, this may cause the belt to heat up and break, but all things considered, belts are cheaper to replace than motors.
5. b. A radian is defined as the angle enclosed by an arc of the circumference equal to the radius. That means that there are  $2\pi$  radians in a circle and that a radian is  $360^\circ/2\pi$  or  $180^\circ/\pi$ . A radian is approximately  $57.3^\circ$ .
6. c. The foot-pound is not a measure of Power; it is a measure of Torque. Power is the rate of doing work or using torque, so that a foot-pound per second is a measure of power.
7. a. Torque and speed are trade-offs. When one goes up, the other goes down. Gearing has no bearing on either the speed or the power of the

motor, which are constants.

8. b. The contact of a wheel on the ground is essentially a line, equal to the width of the wheel. A tread, on the other hand, has a contact area equal to the width of the tread times the distance between the two tread hubs. This gives the robot much more area between the robot and the ground to transfer useful power.
9. c. It is the friction between the belt and the pulleys that transfers the power. As friction between the belt and the pulleys decreases, slippage occurs and power transfer decreases. In industry, rosin dust is spread between the belt and the pulleys to increase sliding friction between the two surfaces.
10. a. Compound pulley ratio is exactly the same as compound gear ratio.