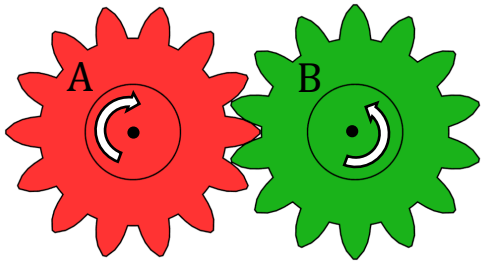
5.4.4 Gears

Gears are mechanical devices for transmitting turning effects (moments). More importantly they are devices for amplifying or reducing turning effects.



Gears are circular wheels with 'teeth' cut into the outer rim. The teeth of one gear mesh (or interlock) with another, so that when one gear turns, the other turns (but in the opposite direction).

(1) Gears A and B are the same size. How would the rotation speed of A compare to the rotation speed of B?

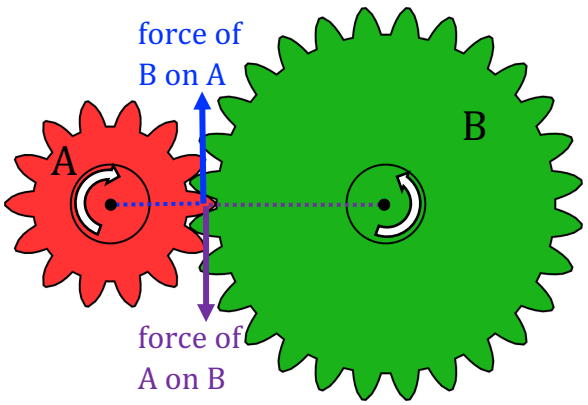
(2) If gear B has twice the radius of gear A, how would the rotation speed of B compare to that of A? Explain.

(3) The diagram shows that gears A and B rotate in opposite directions. If a gear C was connected to gear B, what direction would it turn?

Gears are commonly found in cars. Various gear combinations can be selected by the driver depending on the speed of the car and the force required to be transmitted to the wheels of the car.

(4) Which of the following situations would require a larger force to be applied to the wheels: a) accelerating a car from rest, or b) keeping the car moving at a constant speed along a flat road? Explain.

Consider the following gear combination:



Gear A is connected to the car engine, and gear B is connected to the wheels.

From Newton's 3rd law, where the teeth are in contact, the force of gear A on gear B is equal in size (and opposite in direction) to the force of gear B on gear A.

The forces lead to a turning effect (or moment).

Remember that:

$$moment = force \times perpendicular\ distance\ to\ pivot$$

In this case the gears pivot around the centre of the gear.

(5) Explain why gear B experiences a greater turning effect (moment) than A.

(6) If gear B is twice the radius of A, how will the turning effects (moments) compare?

A car wheel will require a bigger applied moment when there is greater force required between the wheel and the road surface (e.g. going slowly up a hill). To obtain this greater moment, a combination of gears is selected (called 'low gear'), which allows the turning effect (moment) to be increased, but which reduces the speed of rotation.

(7) Which gear would be larger (A or B) in this situation?

A car wheel won't require a big moment to be applied when there is a small force required between the wheel and the road surface (e.g. maintaining a high constant speed of a flat surface). To obtain this smaller moment (but high speed), a combination of gears is selected (called 'high gear'), which allows the turning effect (moment) to be reduced, but which increases the speed of rotation.

(8) Which gear would be larger (A or B) in this situation?

Work done

When a force is used to move an object, work is done. We write:

$$work\ done = force \times distance\ moved\ in\ direction\ of\ force$$

(9) What units do we use for work done?

The work done by the engine in turning gear A is equal to the work done by gear B in turning the wheels (assuming 100% efficiency).

(10) Explain how the work in turning gear A is equal to the work in turning gear B. (Hint: Think about the distances moved by the outer rims of the two gears.)

(11) In reality, gear systems (transmission systems) are never 100% efficient. Explain why.