Using a Four-bar Linkage for a Lifting Arm in a Fighting Robot

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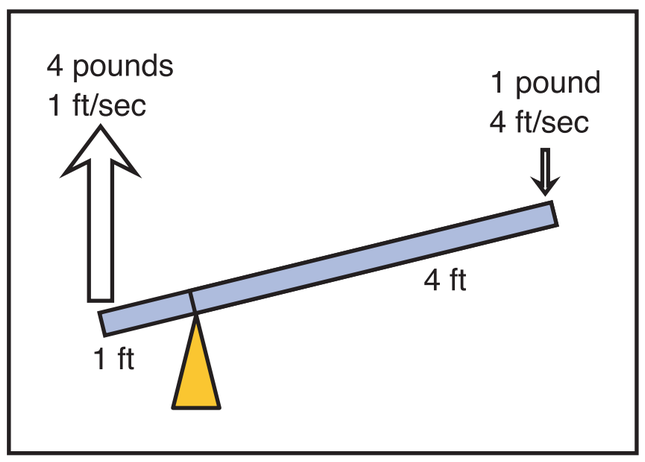
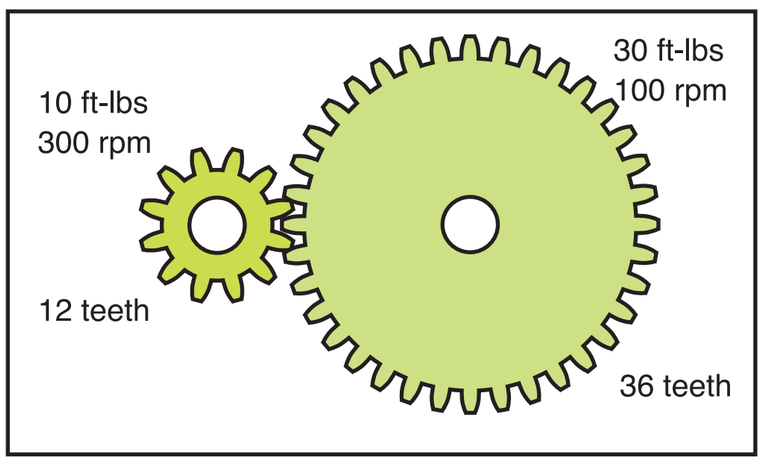
Leverage: trading speed for force

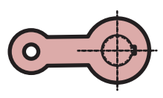


Gear Reduction: trading rpm for torque

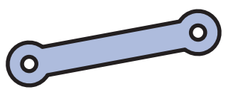


Four-bar linkage converts rotation into lifting motion

Crank arm:
rotates on powered drive shaft

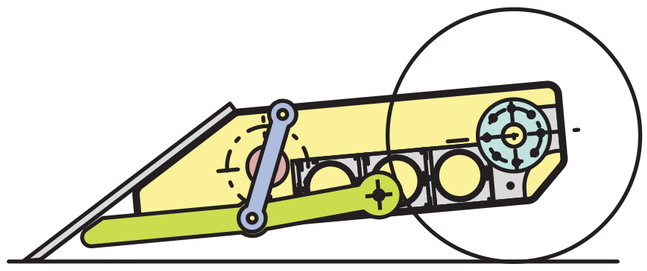


Coupler arm:
rotates freely

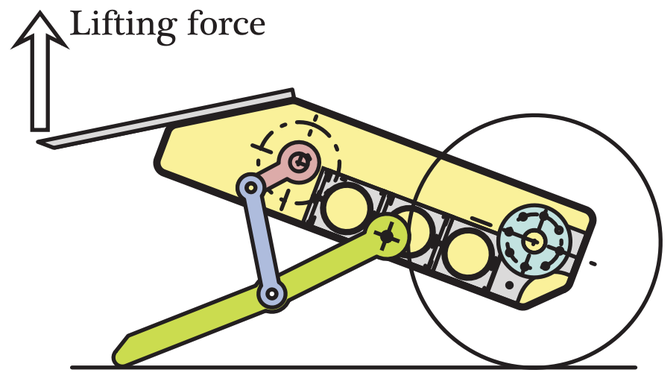


Rocker arm: rotates on hinge fixed to frame.
Front is extended to form "lifting arm".

Frame: the body of the robot counts as fourth "bar"



Retracted



Extended

(1) An A28-150 AmpFlow weapon motor running at 24V spins at 5,450 rpm.
(2) A 64:1 plantetary reduction gear reduces rpm to 85, and increases torque.
(3) A two-stage roller chain and sprockets provide a further 7 : 1 reduction in rpm.
(4) A slip clutch in the roller chain limits the maximum torque on the crank arm to 270 ft-lbs. The clutch also prevents the motor from stalling when the crank arm hits the "up stop" or the "down stop", or if the lifting arms hit an obstruction. This prevents damage to the motor, gears, chains, sprockets and electrical system.
(5) Rotating the crank arm forward pushes down on the coupler, which in turn pushes down on the rocker arm, which lifts the nose of the robot.

Rotational speed versus torque:

Motor	5,450 rpm 0.6 ft-lb	Fast/Weak
Gears (64 : 1)	85 rpm 38 ft-lb	
Chain (7.1 : 1)	12 rpm 270 ft-lb	
Four bar (2.3 : 1)	2-1/2 seconds 620 ft-lb	
Lift with 17" arm	1 foot lift 2-1/2 seconds 440 pounds	Slow/Strong

Variable Leverage:

Unlike gears and sprockets, the four-bar linkage provides varying amounts of leverage through out its range of motion. This particular arrangement gives 10x leverage after 25 degrees of crank arm rotation, and 5x leverage after 50 degrees. This means the robot can lift a lot of weight an inch or so before the clutch starts to slip. The maximum lift is 440 pounds a total of 12 inches, because the robot must lift itself and the opponent together.