2. SISTEMAS Mecánicos TÍPICOS.

To be more concrete regarding classes of mechanical system kinematic and dynamic applications to be considered in the course, it is helpful to review a few typical engineering applications.

2.1. Single Pendulum.

An example of a simple mechanical system is the single pendulum, shown in Fig. 6. This system contains two bodies-the pendulum and the ground.

Imagen 4.6. Ejemplos del sistema mecánico simple: pédulo simple.

2.2. Four-Bar Linkage and Slider Crank Mechanism.

Examples of more complex mechanical systems are the four-bar linkage and the slider-crank mechanism, shown in Fig. 7 and 8, respectively. The four-bar linkage is the most commonly used mechanism for motion transmission. The slider-crank mechanism finds its greatest application in the internal-combustion engine.

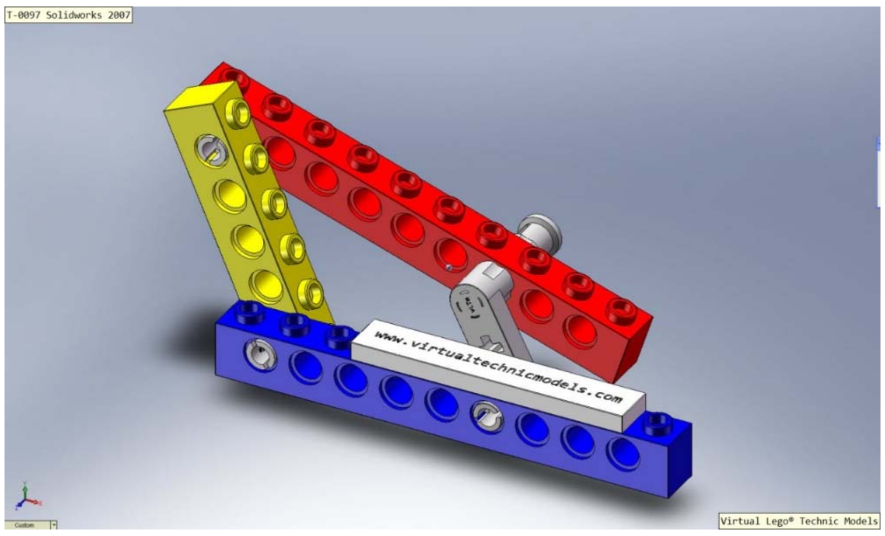
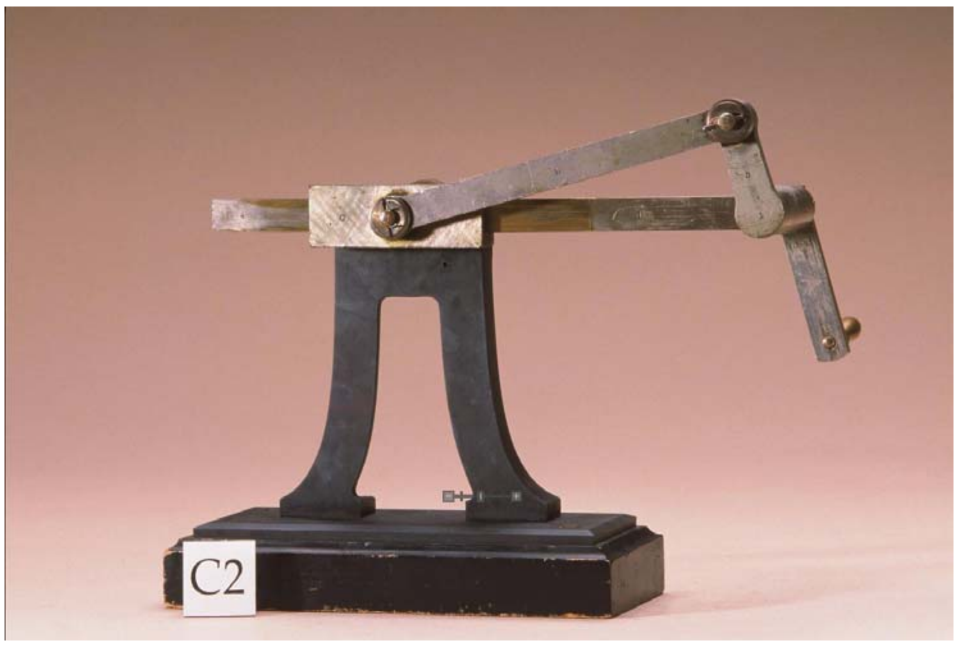
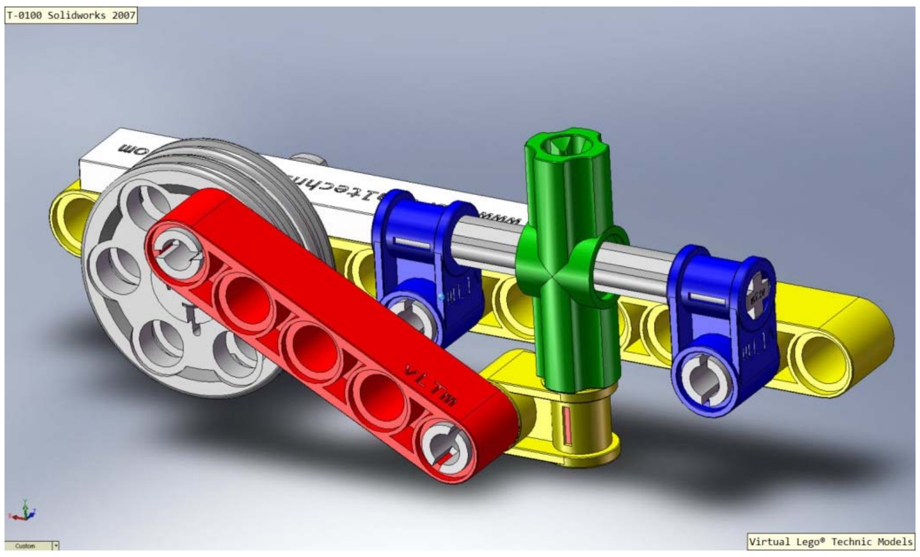


Imagen 4.7. Ejemplos de sistema mecánico simple: mecanismo cuatro barras o cuadrilátero articulado.





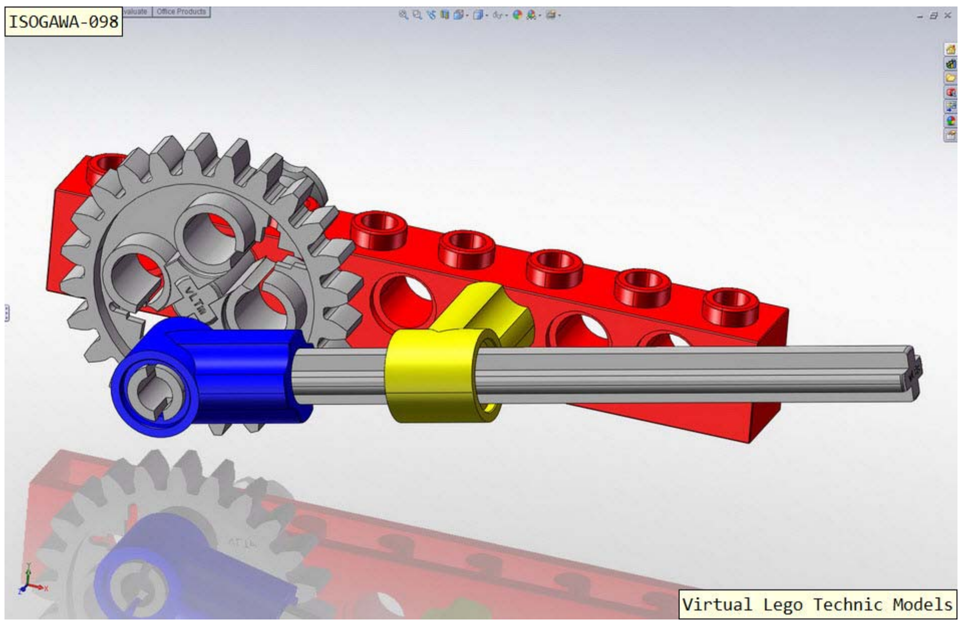


Imagen 4.8. Ejemplos de sistema mecánico simple: mecanismo deslizadera-manivela o triangulo de lado variable.

2.3. V-8 Engine.

The V-8 engine shown schematically in Fig. 9 contains many moving parts and illustrates a number of the most common mechanisms employed in machine design. The crankshaft of the engine rotates in lubricated bearings and contains eccentric rotational bearings with connecting rods, which are subsequently coupled through rotational bearings to translating pistons that move in combustion cylinders. The crankshaft-connecting rod-piston assembly comprises what is commonly called a first example of the slider-crank mechanism, which is used in this application and in many other machine components.

The basic purpose of this mechanism is to transfer forces that are induced by combustion of fuel on the pistons into torques that act about the axis of rotation of the crankshaft, hence inducing the rotational motion that is used to propel a vehicle or to drive rotating machinery. Cams are typically used to induce the precisely timed motion of the cam-follower, which controls the position of the valve stem through a rocker arm, to open and close the intake and exhaust valves during engine operation. To close a valve and to maintain contact between the cam and follower, valve springs are used, as shown. While there are numerous other mechanisms within an engine, these basic components provide examples of typical machine elements.

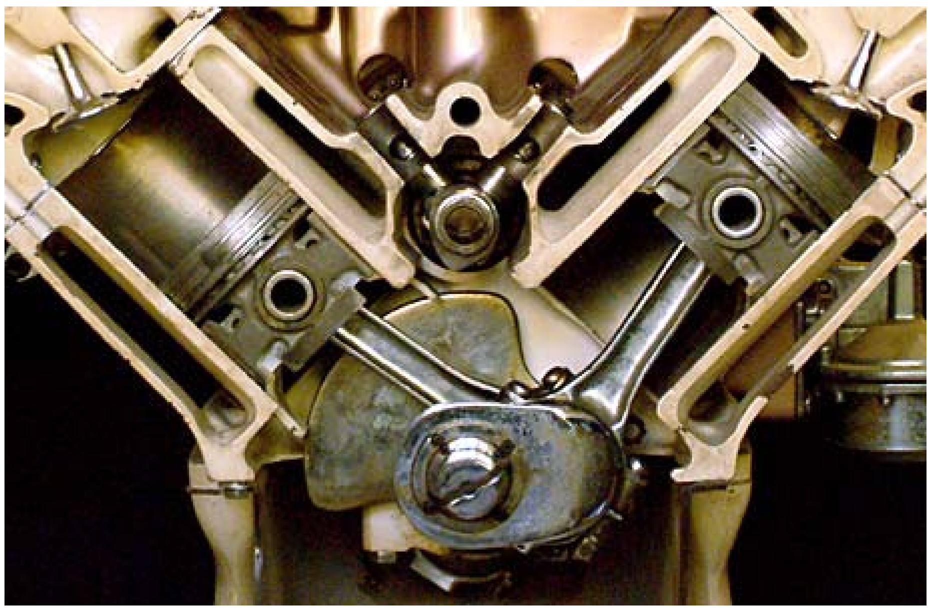


Imagen 4.9. Sección de un motor de 8 cilindros en V.

2.4. Punch Mechanism.

A second application of the slider-crank mechanism is the punch mechanism shown schematically in Fig. 10. The crank is rotated about pivot point O through some angle of oscillation. The coupler, which is pivoted with the crank at point A and with the punch at point B, transmits load to the punch that translates in the machine housing, to provide reciprocating motion of the punch.

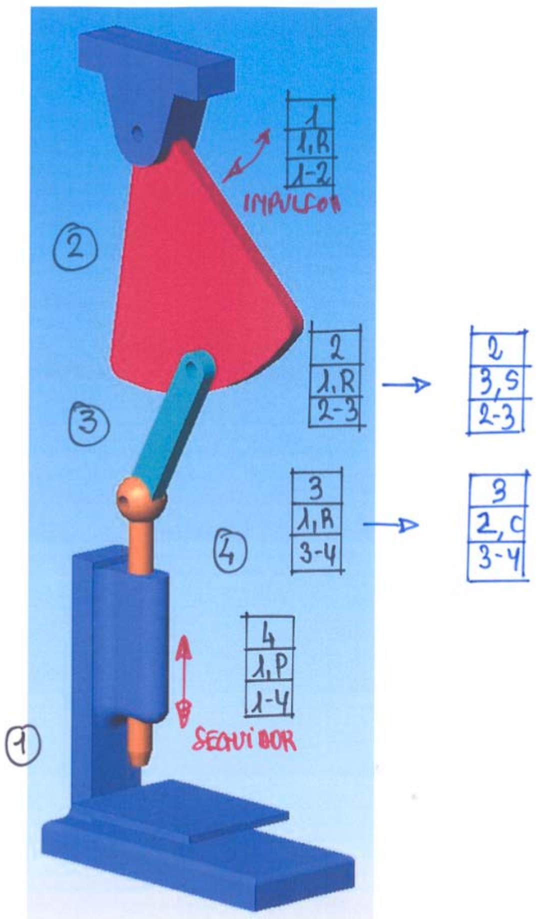


Imagen 4.10. Mecanismo de estampación.

Careful control of dimensions permits a modest torque that acts through a substantial driving angle of the crank to be transformed into a very large force that acts through a short range of motion of the punch, to deform or cut the workpiece.

2.5. Fly-ball Governer.

A third example of a slider-crank mechanism is the fly-ball governer shown in Fig. 11. Relatively massive balls are attached to arms thaf are pivoted to a rotating shaft, so that they rotate with the shaft. Coupler arms are pivoted in the ball arms and a collar that is constrained to translate along the shaft. The ball arms, couplers, collar, and shaft form two slider-crank mechanisms that operate in spatial motion.
This entire mechanism rotates with angular velocity w of the shaft. As the shaft speeds up, centrifugal forces act on the balls to throw them out, causing the collar to move upward, hence increasing the distance s shown in Fig. 11. The purpose of the fly-ball governor is to control the operating speed of an engine. A mechanism couples the position s of the collar to the fuel feed of an intemal combustion engine that drives the shaft. The mechanism is designed so that, at the desired speed of the engine, centrifugal forces on the balls and gravitational and spring forces that act on the mechanism reach an equilibrium state with the collar at a given height.

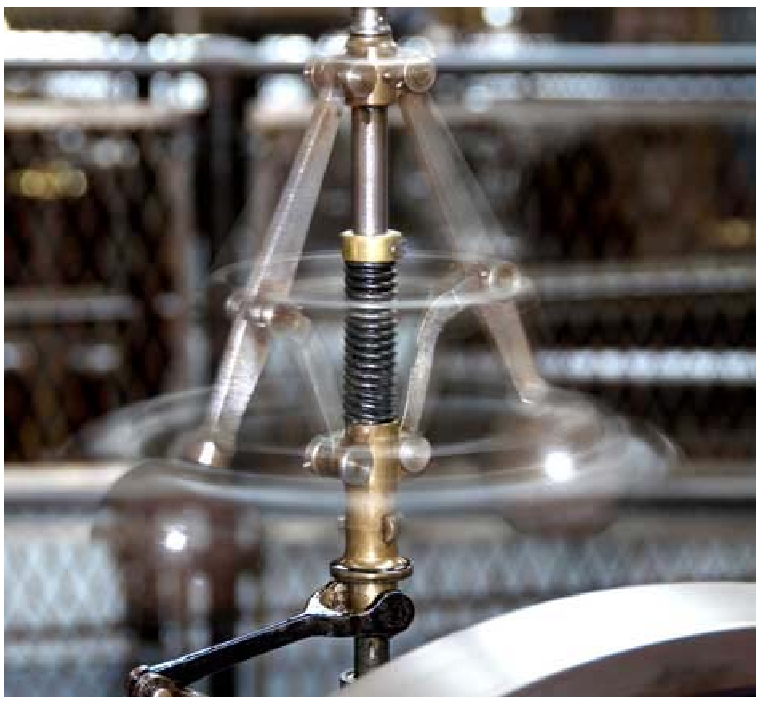


Imagen 4.11. Control centrifuge de bolas.

If an increased load is applied to the engine that reduces the angular velocity w of the shaft (e.g., a vehicle encountering a hill or a lawn mower encountering tall grass), the balls will drop and the collar will move downward. The mechanism that couples the position of the collar with the fuel intake provides additional fuel, which in turn speeds the engine and causes centrifugal forces on the balls to increase, raising the balls toward their nominal height and reducing fuel feed to its nominal value. This is a typical application of a slider-crank mechanism.

2.6. Vehicle Suspension.

Another mechanism that is commonly encountered in mechanical design is the four-bar linkage, such as that shown in the vehicle-suspension application of Fig. 12.

The suspension linkage on each side of the vehicle is made up of upper and lower control arms that are pivoted in rotational joints in the frame and in the wheel assembly. This mechanism permits motion of the wheel assembly relative to the frame and transmission of road forces to the frame through a coil suspension spring and shock absorber, as indicated in Fig. 12. The dimensions of the arms and attachments are carefully designed to cause the wheels to remain in as nearly a vertical position as possible during roll motion of the vehicle. Suspension springs and dampers are designed to provide vehicle stability and to transmit loads with small variation to the frame of the vehicle, even though extreme variations in force occur between the tire and road surface.

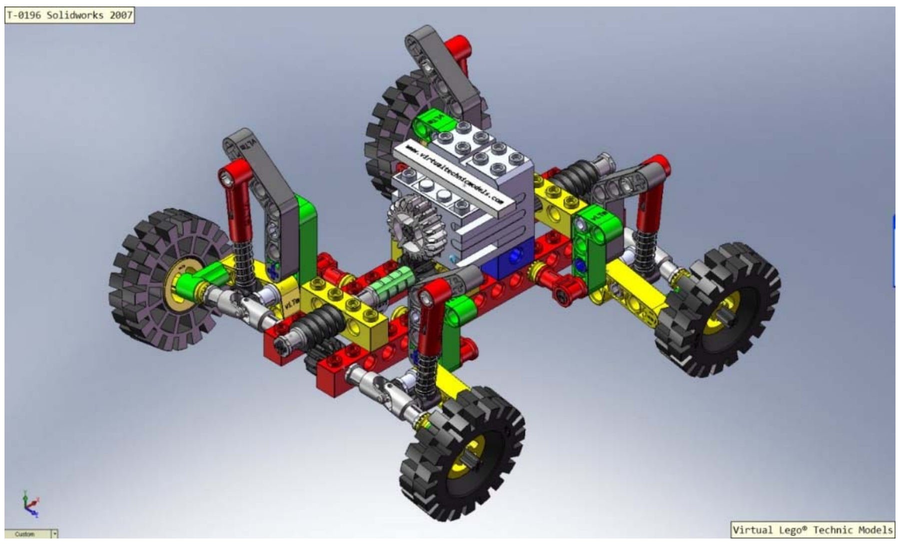


Imagen 4.12. Mecanismo de suspensión de un vehículo.

2.7. Windshield Wiper Mechanism.

The windshield wiper mechanism shown in Fig. 13 is another application of four-bar linkages that transmits motor-driven rotation of the crank to the reciprocating motion of windshield wipers.

Imagen 4.13. Mecanismo limpia parabrisas.

The crank and left rocker arm are pivoted in the vehicle frame at points A and B. The crank coupler is pivoted in the crank at point C and in the left rocker arm at point D. The crank, crank coupler, left rocker, and frame of the vehicle constitute a the first four-bar linkage. Since the distance from B to D is greater than the distance from A to C, a full rotation of the crank causes only a partial rotation of the left rocker arm, leading to the desired reciprocating motion of the left windshield wiper. The dimensions of the various links are carefully selected to generate the desired range of motion. A second four-bar linkage is formed by the right rocker arm that is pivoted in the frame of the vehicle at point G and the rocker coupler that is pivoted in the left and right rocker arms at points E and F. This second linkage transmits reciprocating motion from the left rocker arm to the right rocker arm, hence driving the right windshield wiper.

2.8. Material Handling Mechanism.

Still another example of a four-bar linkage is the material-handling mechanism shown in Fig. 14. The crank (body 1) is pivoted in ground (body 4) at point D and with the material handler (body 2) at point C. The material handler is in turn connected to the follower arm (body 3) at point B and the follower arm is pivoted in ground at point A.\

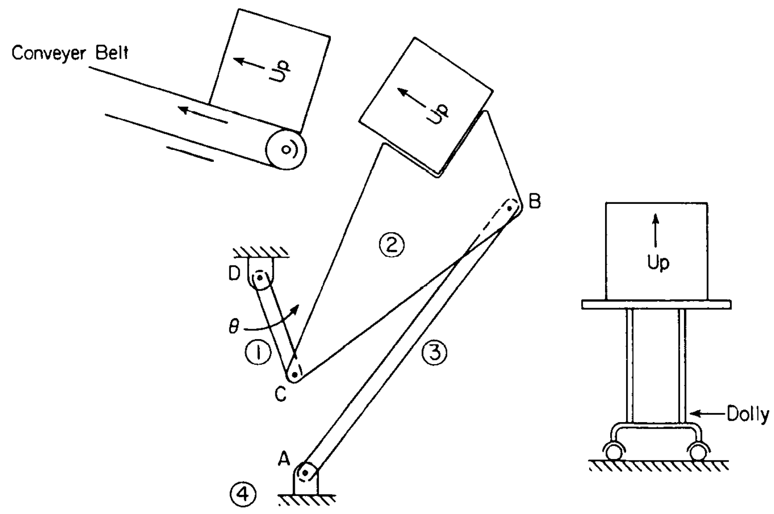


Imagen 4.14. Manipulador de paquetes.

The purpose of the mechanism is to permit counterclockwise rotation of the crank to lower the material-handling arm to a position that permits loading of cargo from a dolly located on the floor. Subsequent clockwise rotation of the crank raises the cargo so that it can be transmitted to a conveyer belt and moved to another station within a fabrication or storage facility. It is geometrically clear from the schematic diagram of Fig. 14 that the dimensions of components of the mechanism must be carefully selected so that the material handler is in the proper position and orientation for both pickup and deposit of the cargo onto the conveyer belt.

2.9. Gears.

Gears, typified by the circular gear pair shown in Fig. 15, are commonly used in mechanical equipment to transmit rotation and torque at varying speeds and magnitudes, respectively, for both control of motion and transmission of power.

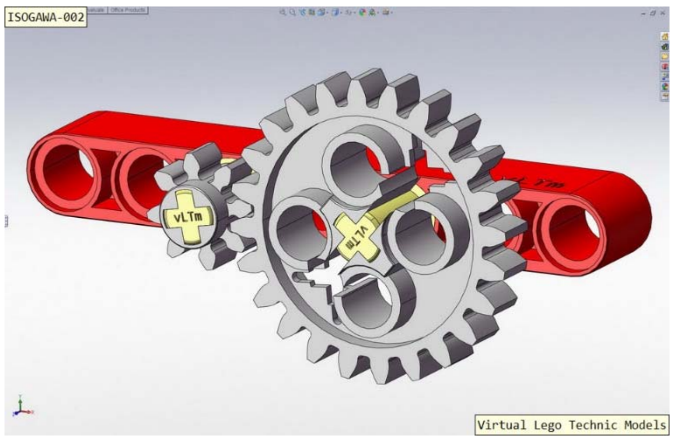


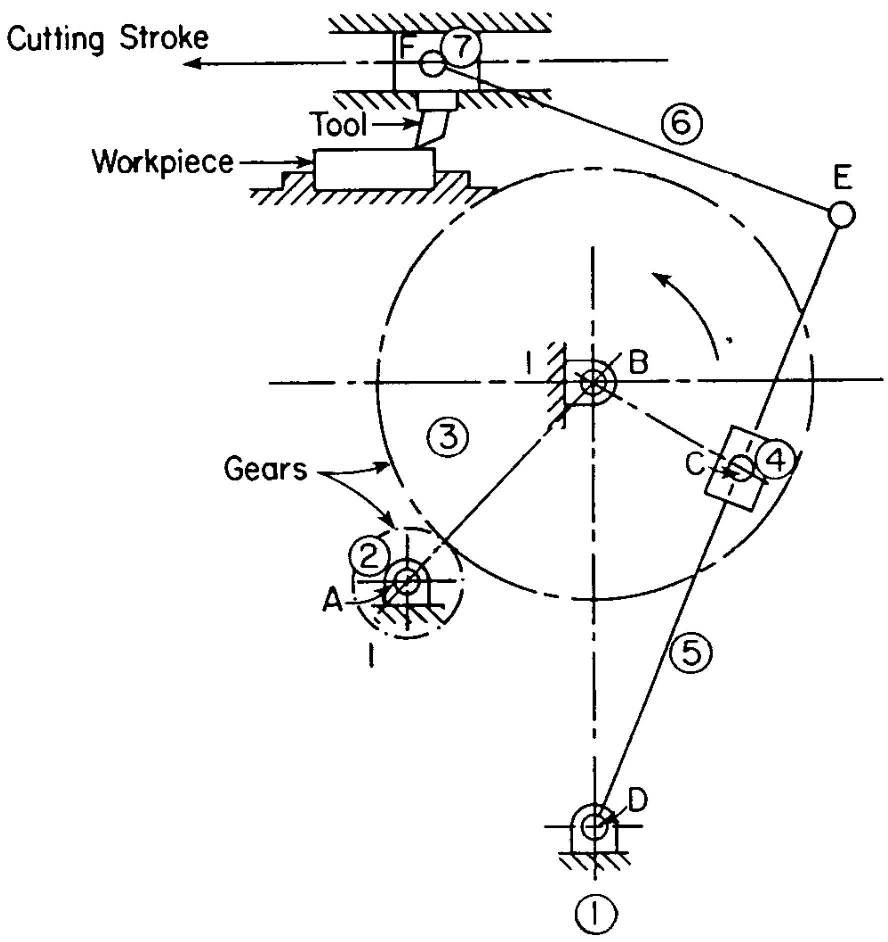
Imagen 4.15. Par de engranajes.

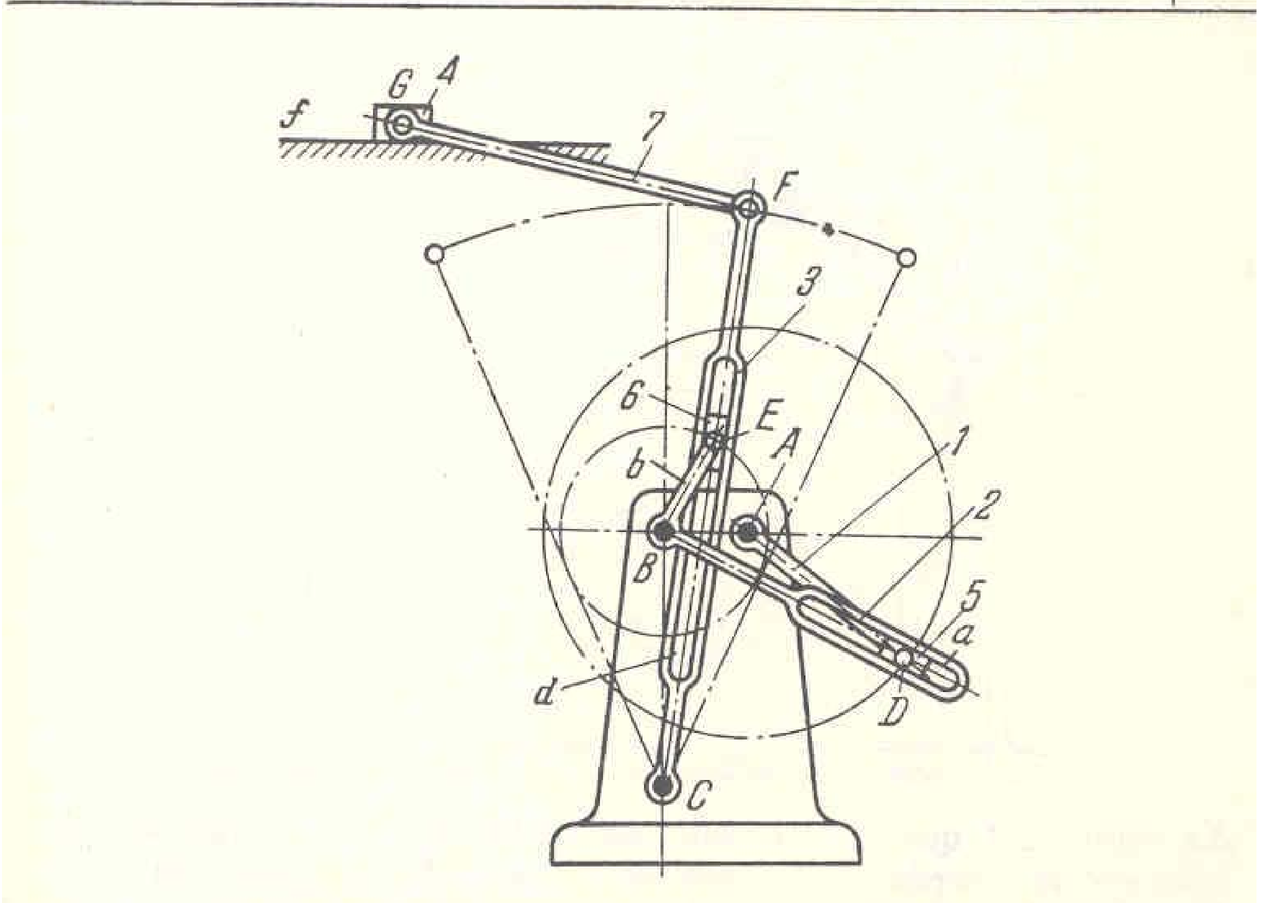
While the details of the design of gear teeth are not treated completely in this course, it is presumed that the geometry of the gears is designed so that continuous contact is maintained at the gear pitch circles, shown in Fig. 15 with radii of 120 and 180 mm. If the smaller gear is driven, the larger gear follows. One full revolution of the larger gear requires 1.5 revolutions of the smaller gear. However, one unit of torque applied to the smaller gear is transmitted as 1.5 units of torque to the shaft of the larger gear. Gearing mechanisms, therefore, permit great latitude in the adjustment of speeds of shafts and torques transmitted.

2.10. Compound Mechanisms: Quick-Return Shaper Mechanism.

Compound mechanisms, such as the quick-return shaper mechanism shown schematically in Fig. 16, are made up from combinations of many of the basic kinematic couplings that have been encountered in the preceding examples.

In this application, body 1 is designated as ground. Bodies 2 and 3 are gears of substantially different pitch diameter, with gear 2 pivoted in ground at point A and gear 3 pivoted in ground at point B. A motor drives the shaft of gear 1, resulting in smaller angular velocity of the larger gear. A coupler, body 4, is attached to the larger gear with a rotational joint at point C. A rocker arm, body 5, is pivoted in ground at point D and slides freely through the coupler of body 4. Thus, as body 3 rotates, body 5 undergoes an oscillating motion. Another coupler, body 6, is connected by rotational joints with body 5 at point E and with the slider, body 7, at point F. Body 7 translates relative to ground and carries a cutting tool that contacts a workpiece and removes material.





1458 | MECANISMO DE PALANCAS Y COLISA DEL TIPO DE UNA LIMADORA | PC ODI

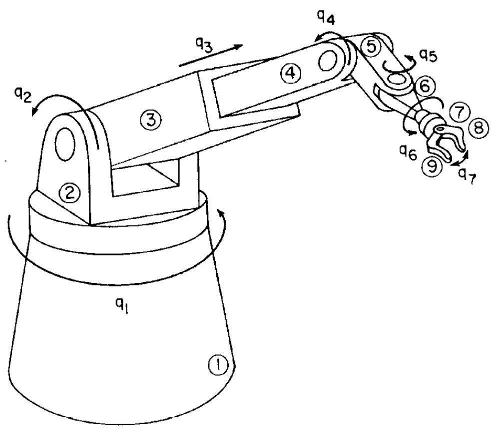
La manivela *1*, que gira alrededor del eje fijo *A*, forma el par de rotación *D* con la corredera *5*. La corredera *5* se desliza en la ranura *a* de la colisa *2* que gira alrededor del eje fijo *B*. La colisa *2* tiene un vástago *b* que forma el par de rotación *E* con la corredera *6* que se desliza por la ranura *d* de la colisa *3*. La colisa *3* forma el par de rotación *F* con la biela *7* que forma el par de rotación *G* con la corredera *4*, la cual se desliza sobre la guía fija *f*. Cuando la manivela *1* gira uniformemente, la colisa *2* gira irregularmente, la colisa *3* efectúa movimiento de vaivén y la corredera *4* efectúa, en una parte de su recorrido, movimiento alternativo aproximadamente uniforme.

Imagen 4.16. Mecanismo de retorno rápido.

By carefully selecting the dimensions of the components of the machine, the cutting tool can be made to move to the left (the cutting stroke) at relatively low speed and to return more quickly to the beginning of the cutting stroke.

2.11. Three-Dimensional Systems: Robot.

While the motion of the systems in previous figures are planar (two-dimensional), other mechanical systems may experience spatial (three-dimensional) motion. For example, the robot, or manipulator, of Fig. 17 is made up of nine bodies, including ground (body 1).



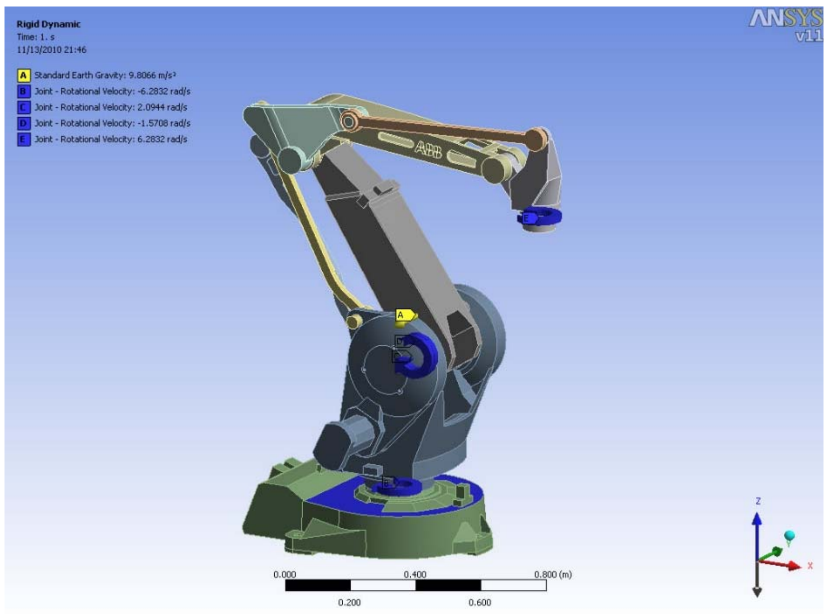


Imagen 4.17. Robot manipulador.

The first degree of freedom is the rotation angle q1, of the base (body 2) about a vertical axis fixed in ground. The second degree of freedom is the rotation q2 of the pivot arm (body 3) about the horizontal axis fixed in body 2. The third degree of freedom is translation q3 of the boom (body 4) in a guide that is fixed in body 3. The fourth degree of freedom is rotation q4 of the first wrist pivot (body 5) relative to body 4. The fifth degree of freedom is rotation q5 of the second wrist pivot (body 6) relative to body 5. The sixth degree of freedom is rotation q6 of the hand mechanism (body 7) relative to body 6. The final degree of freedom is relative rotation q7 of the robot fingers (bodies 8 and 9).

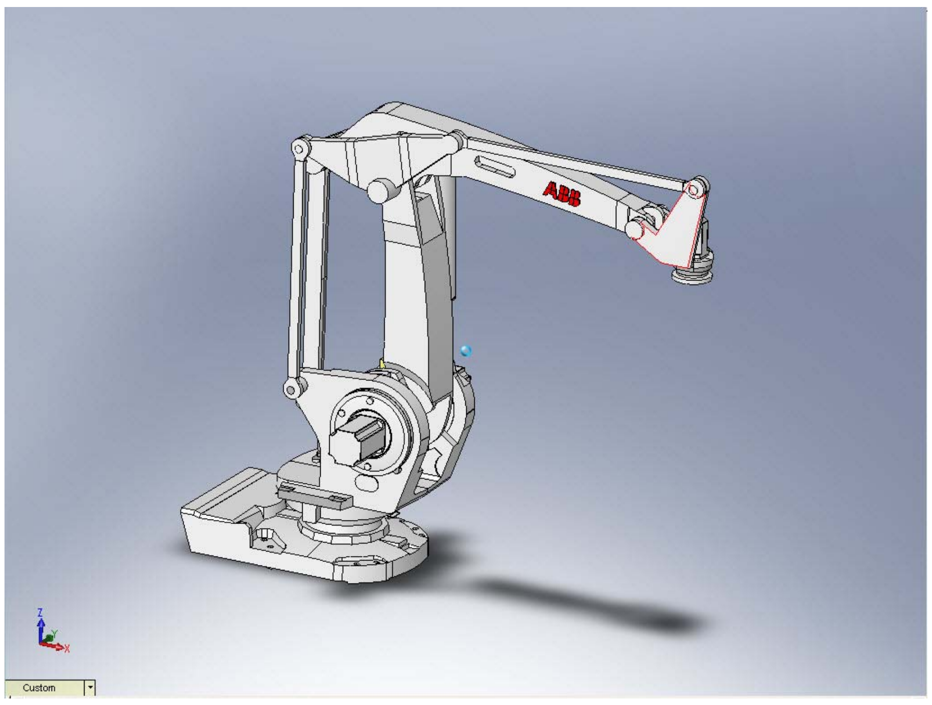


Imagen 4.18. Robot con base estacionaria.

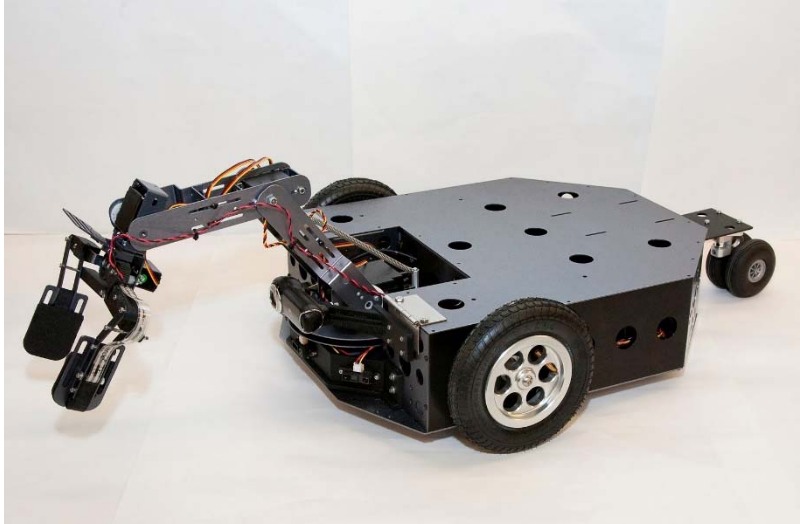


Imagen 4.19. Robot con base móvil.

Such a mechanism permits the end-effector to grasp and manipulate workpieces. A robot can be fixed to a stationary base or to a movable base, as shown in Fig. 19. The motion and the position of the end effector of a robot are controlled through force actuators located about each joint connecting the bodies that make up the robot.

2.12. Vehicle Suspension System.

The final compound mechanism example that illustrates the scope of study to follow is the vehicle of Fig. 20, whose suspension system is shown schematically in Figs. 21 and 22.

Imagen 4.20. Automóvil.

This commonly employed high performance vehicle suspension consists of a McPherson strut front suspension and a trailing arm rear suspension. Each front wheel assembly is attached to the chassis of the vehicle through a lower control arm and a telescoping strut assembly, as shown in Fig. 21.

Imagen 4.21. Suspensión delantera tipo McPherson.

Concentric with the strut assembly are suspension spring and damping components. The spherical joints at the top and bottom of the strut assembly permit steering rotation of the wheel assembly about the strut. The more elementary rear suspension shown in Fig. 22 is simply a control arm that is pivoted in the chassis to permit the rear wheel assembly to move relative to the chassis.

Imagen 4.22. Esquema de la suspensión de un automóvil.

Spring and damping components attached between the rear control arm and chassis provide for support of the chassis and cushioning of extreme tire-road forces.

These examples represent typical machines that are encountered in mechanical system kinematic and dynamic analysis and design. The breadth of such applications is extensive. While applications and environments differ greatly, many technical similarities permit the development of a uniform approach to computer-aided kinematic and dynamic analysis.