

## ME345 Modeling and Simulation

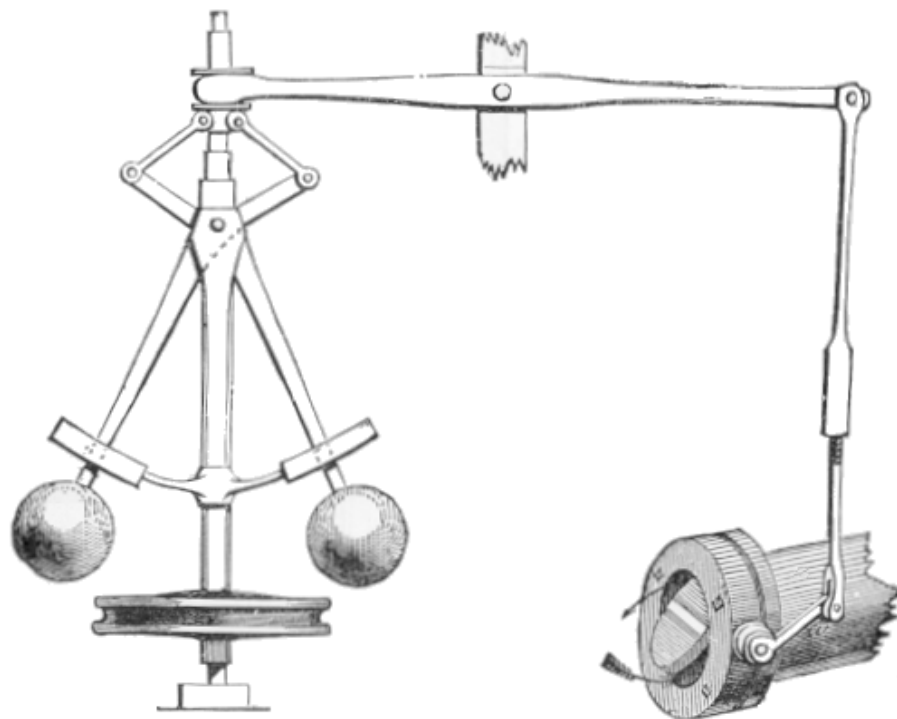
### Centrifugal Governor Analysis

In engineering, any device that controls the speed of a machine or engine, usually by regulating the intake of fuel or steam is called a governor.

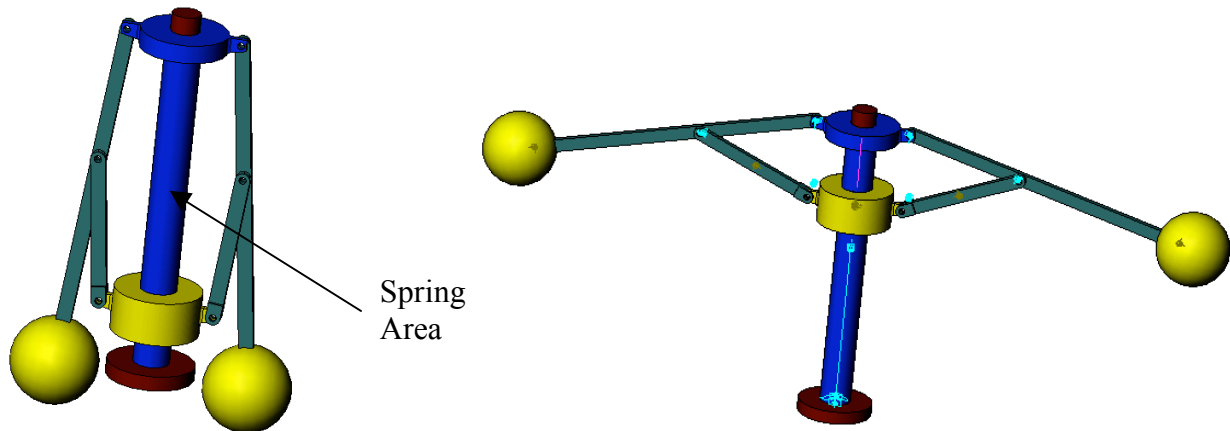
A **centrifugal governor** is a specific type of governor that controls the speed of an engine by regulating the amount of fuel admitted, so as to maintain a near constant speed whatever the load or fuel supply conditions. It uses the principle of **proportional control**.

It is most obviously seen on steam engines where it regulates the admission of steam into the cylinder(s). It is also found on internal combustion engines and variously fueled turbines.

The device shown is from a steam engine. It is connected to a throttle valve and to the prime mover (not shown). The action of the governor is dependent on centrifugal force. As the speed of the prime mover increases, the central spindle of the governor rotates at a faster rate and the two masses move outwards, and this motion is translated by the series of rods and arms to the throttle valve, reducing its aperture. The rate of steam entering the cylinder is thus reduced and the speed of the prime mover falls. If the speed of the prime mover falls, the reverse effect occurs and the throttle valve opens further.



In other words, when the engine speed increases too much, the balls fly out, and cause the stem valve to close, so the engine slows down. The opposite happens when the engine speed drops too much.



### Problem Statement:

The governor mechanism shown above, has an initial angular velocity of 360 deg/s and over 4 seconds, the angular velocity increases to 1440 deg/s (the initial velocity is 360 deg/s). There is an uncompressed spring (this a modification of the original design), which has a stiffness of  $k = 0.9 \text{ N/mm}$  (damper = 0.1 N-sec/mm), and is connected from the top center of the slider to the rotating collar where  $z = 345 \text{ mm}$ .

As the governor rotates, determine the distance  $z$  corresponding to the maximum compression of the spring. (When the Fly balls are on the top)

Note: In order to add motion, use the following data.

Add Motion

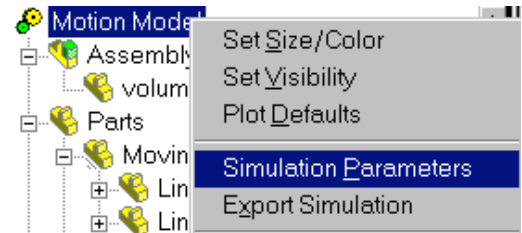
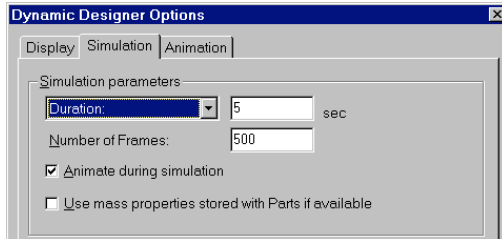
- *Function = Step*
- *Initial value = 360 deg/s*
- *Final Value = 1440 deg/s*
- *End Step Time = 4 sec*

In order to create a spring constraint in the motion mechanism, you do not have to create any CAD model (spring), just right click on springs / dampers (Forces Constraints on the tree motion design) and select add linear spring/add linear damper

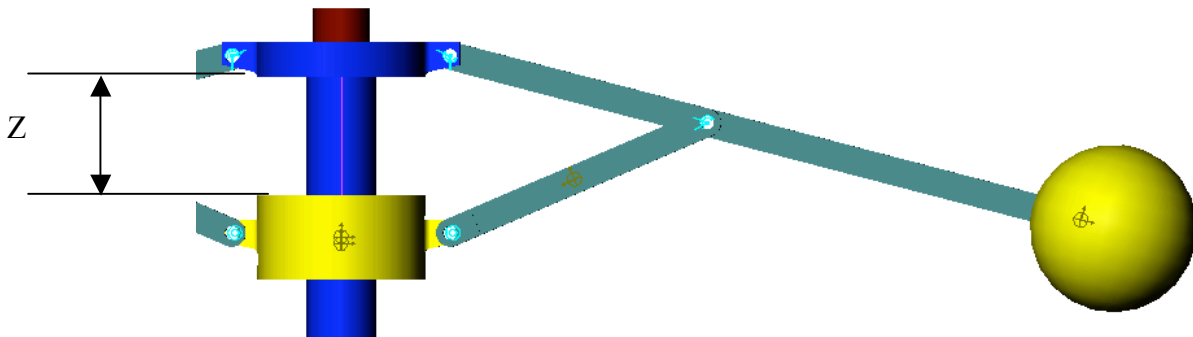


➤ Simulation Parameters

- *Time = 5 sec*
- *Frames = 500*



Calculate the distance,  $z$ , between slider and rotating collar

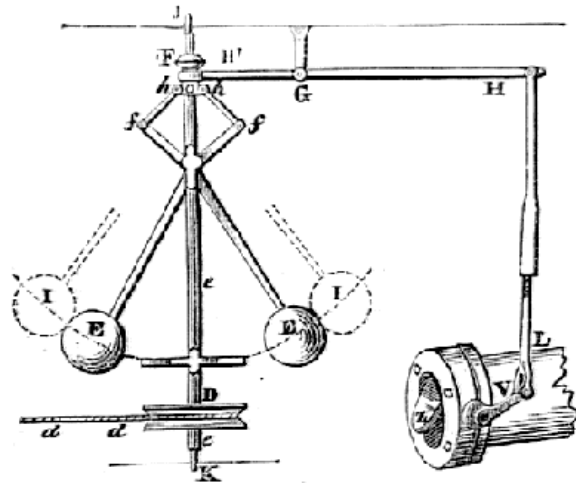
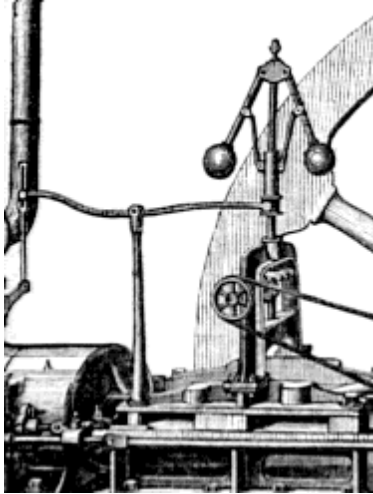


Note:

All the elements to create the Governor Assembly are supplied; take into account to create the simulation of this mechanism you have to create the governor assembly first.

## Additional Information

The application of this device to the steam engine has a great importance in the technology history because it was the founder of a great family of devices for the installations automatic control. If the engine gained excessive speed, centrifugal force drove the balls and the balls the steam valve. The engine then slowed



A **proportional control** system is a type of linear feedback control system. Two classic mechanical examples are the toilet bowl float proportioning valve and the fly-ball governor.

The proportional control system is more complex than an on-off control system like a thermostat, but simpler than a proportional-integral-derivative (PID) control system used in something like an automobile cruise control.

An on-off control is like driving a car by applying either full power or no power to control speed. The power would be on until the target speed is reached, and then the power would be removed, so the car reduces speed. When the speed falls below the target, full power would again be applied. It can be seen that this is poor control.

**Proportional control** is how most drivers control the speed of a car. If the car is at target speed and the speed increases slightly, the power is reduced slightly, or in proportion to the error (the actual versus target speed), so that the car reduces speed gradually and reaches the target point with very little, if any, "overshoot", so the result is much smoother control than on-off control.

Further refinements like PID control would help compensate for additional variables like hills, where the amount of power needed for a given speed change would vary, which would be accounted for by the integral function of the PID control.