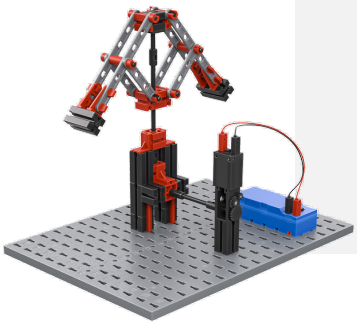
Model 20
Centrifugal force

Date

Name

Class

The students receive the construction manual for building the centrifugal governor.



THEMATIC TASK

1. Ways to reduce centrifugal force:
   - Reduce speed.
   - Increase the radius, i.e., do not take the curve so tightly.

   If the curve is predetermined, e.g., by a road, the speed must inevitably be reduced in order to reduce the centrifugal force and avoid danger.

2. You can calculate the centrifugal force using the formula:

$$F = \frac{v^2}{r}$$

   - F is the centrifugal force in newtons [N]
   - m is the mass in kilograms [kg]
   - v is the speed in meters per second [m/s]
   - r is the radius of the circle/curve in meters [m]

   To prevent the rotating body from flying away, a counterforce equal to the centrifugal force is always exerted. This is called centripetal force. On a carousel, the force acts along the ropes toward the center of rotation.

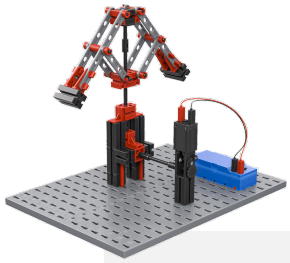
3. Radial acceleration (centripetal acceleration): $F = m \cdot a$

   a is the radial acceleration in meters per square second (m/s^2)

   Note: Centripetal force and centrifugal force have the same formula. They are opposite forces that depend on the reference system. When circular motion is viewed from the outside, only centripetal force acts. If the observer is in the rotating system, they perceive both forces.

   Angular velocity: $F = m \cdot r \cdot \omega 2$

   ω is the angular velocity in radians per second (rad/s). It is calculated by $\omega = 2\pi \cdot f$ (f = frequency of the circular motion)



EXPERIMENTAL TASK

Date

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1. B15 increases with increasing speed (ω rotating axis)
2. α increases with increasing speed (ω rotating axis)
3. B15 lowers as the weights M increase
4. α becomes smaller when the weights M increase

5.

The centrifugal governor was operated by a belt over the piston of a steam engine. At rest, the throttle valve of the steam pipe to the steam engine is fully open. As the piston of the steam engine moves, the centrifugal regulator begins to rotate. As the rotational speed increases, the weights on the arms are lifted further and further. The height (B15) regulates a throttle valve via a joint and lever mechanism, which controls the steam to the engine.

The greater the height (B15), the more closed the throttle valve is. This allowed the working speed of the steam engine to be kept constant.

The steam engine then runs more slowly until a stable state or constant speed is reached.

APPENDICES

Building instructions and templates for the models:
Model 20: Building instructions for the centrifugal governor model.

Further information

[1] Wikipedia: Centrifugal force
[2] LeifiPhysik: Centrifugal governor
[3] studyflix: Centrifugal force