Unit-06　Centripetal Force Experiment

Objective：

Circular motion is one of basic motions in the world. For example, spin of electron in the atom and interaction between planets…etc. In this lesson, we would find out the relation of centripetal force with mass, radius, and rotation velocity by studying the circular motion in constant velocity.

Apparatus：

Centripetal force set, rotating body, balance body, weight, photogate, force sensor, digital device, analogy device, DC power supply, level, electronic scales

Principle：

When a body with mass m is in constant velocity v horizontal circular motion with radius r, the centripetal force F_C can be expressed as:

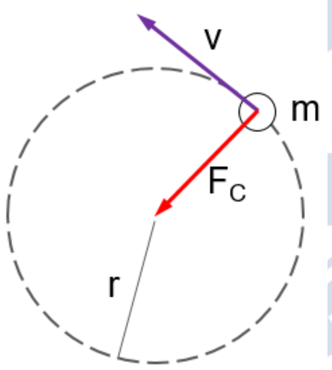

Figure 1. Centriprtal force simulation

$$F_C = \frac{mv^2}{r} \quad (1)$$

By equation (1), v is tangent velocity of the body, ω is angular velocity of the body, and m is the mass of the body.

In centripetal force, the tangent velocity v can be expressed as

$$v = r\omega = \frac{2\pi r}{T} \quad (2)$$

By equation (2), T is period

By equation (1) and (2), the object centripetal force F_C, the angular velocity ω and the period T are expressed as follows

$$F_C = \frac{mv^2}{r} = \frac{m(r\omega)^2}{r} = mr\omega^2 = \frac{4\pi^2 mr}{T^2}$$

Figure 2 for the centripetal force experimental device diagram, m_1 is rotating, m_2 is balance body and FS for the force sensor (Force Sensor).

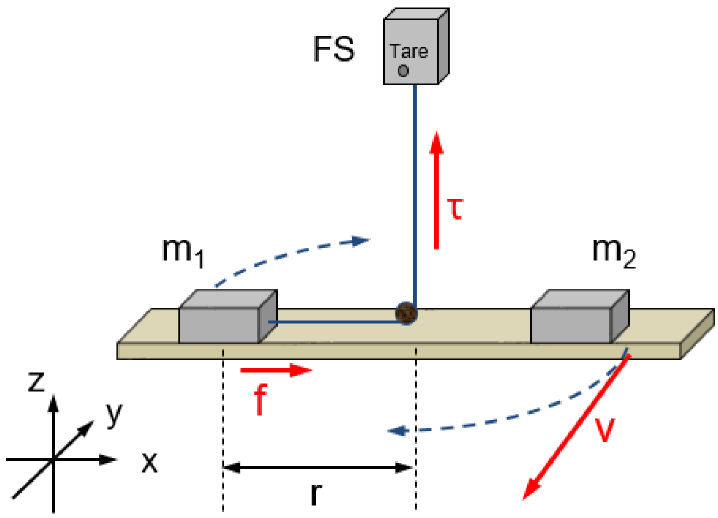

Figure 2. Centripetal force experimental device diagram

The centripetal force is increased gradually as the velocity of the body increase. The centripetal force can be expressed as

$$F_C = \tau + f = m_1 r\omega^2$$

$$f = m_1 \mu g$$

τ: tensor of cable, f: static friction between body and track, μ :static friction coefficient, m_1: mass of body, r: radius of circular motion of the body, ω : angular velocity.

[Note] If the centripetal force is larger than the static friction between the body and the track, the body will slid out of the track.

Remarks：

1. Before rotate the plate, make sure all screws are locked tightly. Serious damage may happen to your eyes.
2. Do not pull or push the force senor (FS) hardly to protect the apparatus.
3. The positive means pushing from cable to force senor and vice versa.
4. Motor would be broken over 10.0 Volts applied.
5. To confirm the height position of photogate height position.

Procedure：

➢ **Preparation**

1. Put the level on the track, and adjust the base screw to keep the track horizontal.
2. Adjust the position of the pulley seat and fixed it on the center rail.
3. Set the pulley in the middle of the track; connect force detector and rotating body by cable.
4. Connect rotation platform and motor by O-ring.
5. Due to rotating body and balance body have different masses, use weights to keep the same mass.
6. Adjust the height position of force senior to change the rotation radius.
7. Rotating body and balance body should maintain the same mass, but weights have slightly different between each other. Measure the mass of the body through electric steelyard, and record it actuality.

A. Fix the radius *r* and mass *m*, and vary angular velocity ω

1. Keep the mass of rotating body m_1 and radius r.
2. Place the balance body on the other side, its mass and radius are the same with rotating body.
3. Push「Tare」on the force detector after make sure the rotating body is force-free horizontally.
4. Open the software and set the parameters by instruction book.
5. Trigger the motor in 6.0 volts.
6. Press down button to start capture data. Simultaneously observe『angular velocity - time』and『tensor of cable - time』chart for 20-30 seconds.
7. Capture average and record the angular velocity ω of track and tensor τ of cable.
8. Keep the radius and the mass of the body mentioned above. Change the output power (change angular velocity) and repeat above steps. (**Don't over 10 volts**)
9. Plot $F_C(\tau)-\omega^2$ diagram.

B. Fix the angular velocity ω and mass *m*, and vary radius *r*

1. Keep the mass of rotating body m_1 and angular velocity ω.
2. Set the mass of rotating body radius *r*.
3. Place the balance body on the other side, its mass and radius are the same with rotating body.
4. Push「Tare」on the force detector after make sure the rotating body is force-free horizontally.
5. Open the software and set the parameters by instruction book.
6. Trigger the motor in 6.0 volts.
7. Press down button to start capture data. Simultaneously observe『angular velocity - time』and『tensor of cable - time』chart for 20-30 seconds.
8. Capture average and record the angular velocity ω of track and tensor τ of cable.
9. Keep the mass of body (m_1 and m_2) and rotation velocity (fix angular velocity) mentioned above. Change the radius of gyration and repeat above steps.
10. Plot $F_C(\tau)-r$ diagram.

C. Fix the radius *r* and angular velocity ω, and vary mass *m*

1. Keep the radius of rotating body *r* and angular velocity ω.
2. Place the balance body on the other side, its mass and radius are the same with rotating body.
3. Push「Tare」on the force detector after make sure the rotating body is force-free horizontally.
4. Open the software and set the parameters by instruction book.
5. Trigger the motor in 6.0 volts.
6. Press down button to start capture data. Simultaneously observe『angular velocity - time』and『tensor of cable - time』chart for 20-30 seconds.
7. Capture average and record the angular velocity ω of track and tensor τ of cable.
8. Keep the radius and rotation velocity (fix angular velocity) mentioned above. Change the mass of rotating body m_1 and balance body m_2 at the same time and repeat above steps.
9. Plot $F_C(\tau)-m_1$ diagram.

<u>Questions</u>：

1. Can be derived the static friction coefficient in this experiment? Please explain.
2. What influence it would be to the experiment if the track is not horizontal?