INDOSAW
COMMITTED TO EXCELLENCE

INSTRUCTION MANUAL

CENTRIPETAL FORCE EXPERIMENT
SK202

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Experiment: To demonstrate the independent relationships between centrifugal force and each of the following three variables:

1. F α m,for constant Radius (r) and Angular velocity (ω)
2. F α ω^2, for constant Mass (m) and Radius (r)
3. F α r , for constant Mass (m) and Angular Velocity (ω)

Principle: When a body of Mass 'm' , move in a circle of radius 'r' , with constant speed 'υ' , then centrifugal force acting on body along the radius away from the centre is given by :-

$$F=\frac{(m\nu^2)}{r}$$

$$F=mr\,\omega^2 ----------(1) \qquad v = r\omega$$

where ω = Angular velocity

Theory: Let body of mass 'm' move in a circle of radius 'r' with angular velocity ' ω'. When the body move by small angle δΘ , the velocity changes in direction without change in magnitude , in time δt. To find the change in velocity let OA represent the initial velocity and OB represent the velocity after time δt . Then vector AB represent the change in velocity in time δt.

Then acceleration is equal to time rate of change of velocity

$$a=\frac{(\delta\nu)}{(\delta t)} ----------(2)$$

As angle δΘ is small , in time δt,
then Angular velocity equals to time rate of change of angular displacement.

$$\omega=\frac{(\delta\theta)}{(\delta t)} -----(3)$$

$$\delta t=\frac{(\delta\theta)}{(\omega)} -----(4)$$

Also from fig-2 , $\delta\theta=\frac{(\delta\nu)}{(\nu)}$

or $\delta\nu=(\nu\delta\theta) -----(5)$

Put (4) and (5) in (2) we get,

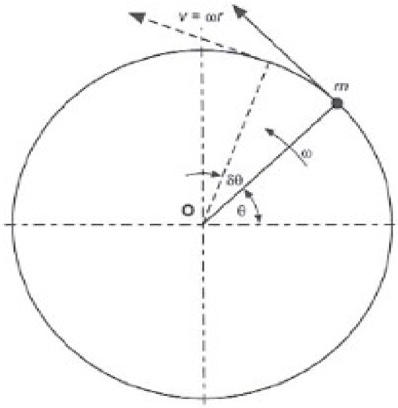


Fig-1

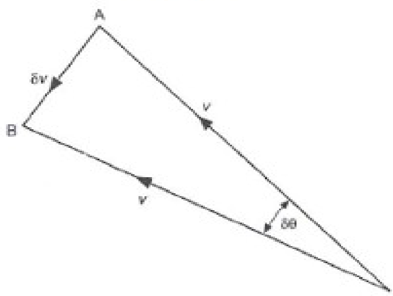


Fig-2

$$a=\nu\omega=r\omega^2 \quad (\text{ as } \upsilon = r\,\omega)$$

This acceleration is called as centre seeking acceleration , because the mass is continuosuly accelerated toward centre. From Newton's 2nd law of motion a force must act on the mass 'm' in the direction of this acceleration .

i.e. Centripetal force , F= m a= m r ω^2--------- (6)

The Inertia force is in opposite i.e. Acting outward from the centre. This force is termed as centrifugal force

i.e. F= m r ω^2--------- (7)

Setting the Apparatus:

- Arrange the apparatus as shown in fig-3.
- Fit the red pointer on the central rod of Blue Car. The pointer measure the distance r (radius) of the centre of gravity of car from the axis of rotation.
- Connect the car with the 2N Spring balance with the help of thread passing over the pulley. The spring balance is pushed down to the maximum posible position.

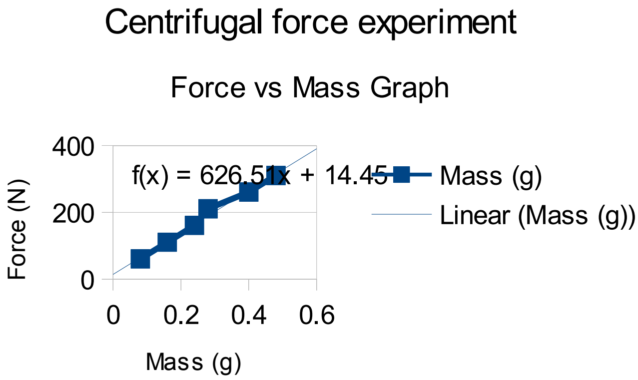
Experimental Procedure To verify the relation between 'F' and 'm' keeping ' ω' and 'r' as constants.

1. Arrange the apparatus as described above without any additional mass on car.
2. Connect the terminals of Motor with 0-12V DC power supply by using connecting leads.
3. Switch on the Motor, and wait till the centrifugal apparatus rotate with constant speed.
4. Record the position of Red pointer on the cm scale.
5. Record the force F by the spring balance.
6. Switch off the power supply.
7. Add weight on the car using provided set of weights .
8. Switch on the power supply .
9. Adjust the spring balance by moving it up so that radius remains same. For setting balance stop Motor and then set the spring balance . Record the reading of Force for mass 'm'.
10. Repeat the experiment for different weights.
11. Plot the graph between 'm' and 'F' taking 'm' along the x-axis and force F along y-axis.
12. The straight line graph justify that Force is directly proportional to mass (i.e. Fα m).

Fig-3

Observation Table:

S.No	Force (N)	Mass (g)
1	0.08	60.7
2	0.16	110.7
3	0.24	160.7
4	0.28	210.7
5	0.4	260.7
6	0.48	310.7



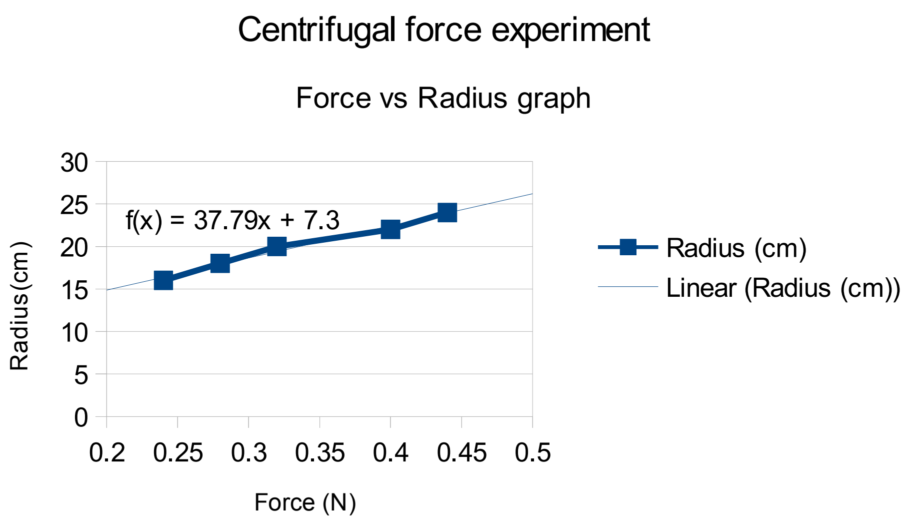
Precaution: When the car moves away from the fixed position of 'r' set the spring balance by moving it up only after stopping the motor.

Experimental Procedure To verify the relation between 'F' and 'r' keeping ' ω' and 'm' constant.

1. Place 150g mass on the car.
2. Select fixed angular velocity of the apparatus .
3. By setting the displacement of spring balance, record the centrifugal force F, fot different radii of the rotating car.
4. Draw the graph with radius 'r' along y-axis and 'F' along x-axis.

Observation Table:

S.No.	Force(N)	Radius(r in cm)
1	0.24	16
2	0.28	18
3	0.32	20
4	0.4	22
5	0.44	24



Experimental Procedure To verify the relation between 'F' and 'ω' keeping ' r' and 'm' constant.

1. Place a mass (say 150 g) on the car.
2. Let 'r' is predetermined radius = 23cm (say).
3. By displacing the spring balance find the Force for different angular velocities (= 2л /T) of car for same 'r'.
4. plot the graph between angular velocity taking along x-axis and Force taking along y-axis.
5. **Note: Angular velocity can be calculated by measuring the time of rotation 'T' using photogate and Digital Timer.**

Process to determine Time Period 'T' using photogate and Timer:

- Connect the photogate on the stand rod using Boss Head.
- Connect the Registered Jack Cable , one end to gate1/gate2 of digital timer and other end to photogate.
- Connect the 5V DC adaptor to the 5V DC socket of digital timer.
- Switch on the digital timer. Set the MODE to 'Time Mode' by pressing the Mode button. Select 'GATE1' by pressing the select switch of the digital timer. Press Start/Stop button to take the readings.

- Place the photogate in such a manner that blue track on which Car rests , passes through the photogate . When it passes through the photogate , timer display the reading of Time Period.
- Use the value of 'T' in below formula to calculate angular velocity.
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$$\omega = \frac{(2\pi)}{T}$$

Observation Table:

S.No.	Force(N)	Time (Sec)	Angular Velocity (ω) S^{-1}
1	0.12	3.5	1.79
2	0.32	2.5	2.51
3	0.56	2	3.14
4	0.8	1.66	3.78
5	1.36	1.27	4.94