V-Collected Data:

Table-8.1 Collected data (speed of motor) for the mentioned states

M_a = 25 gm, r = 12.5 cm		
Trial	m_b(gm)	Speed(rpm)
1	25	0.29
2	50	0.42
3	75	0.49
4	100	0.57

x 360

M_a = 50 gm, r = 12.5 cm		
Trial	m_b(gm)	Speed(rpm)
1	25	0.21
2	50	0.28
3	75	0.34
4	100	0.39

M_a = 75gm, r = 12.5 cm		
Trial	m_b(gm)	Speed(rpm)
1	25	0.18
2	50	0.23
3	75	0.28
4	100	0.32

M_a = 25 gm, r = 9 cm		
Trial	m_b(gm)	Speed(rpm)
1	25	0.34
2	50	0.45
3	75	0.57
4	100	0.65

M_a = 25 gm, r = 8cm		
Trial	m_b(gm)	Speed(rpm)
1	25	0.37 ×300
2	50	0.54
3	75	0.62
4	100	0.71

VII-Results:

Table-8.2 Data processing results

M_a = 25 gm, r = 12.5cm					
Trial	m_b (gm)	w (rad/sec)	m_b (N)	$M_a rw^2$ (N)	Percentage Error(%)
1	25	9.11	0.245	0.258	5.3
2	50	13.19	0.491	0.544	10.8
3	75	15.39	0.736	0.741	0.54
4	100	17.91	0.981	1.002	2.14

M_a = 50 gm, r = 12.5cm					
Trial	m_b (gm)	w (rad/sec)	m_b (N)	$M_a rw^2$ (N)	Percentage Error(%)
1	25	6.60	0.245	0.272	11
2	50	8.8	0.491	0.484	1.42
3	75	10.68	0.736	0.713	3.1
4	100	12.25	0.981	0.938	4.38

M_a =75 gm, r = 12.5cm					
Trial	m_b (gm)	w (rad/sec)	m_b (N)	$M_a rw^2$ (N)	Percentage Error(%)
1	25	5.65	0.245	0.300	22.4
2	50	7.23	0.491	0.489	0.41
3	75	8.796	0.736	0.725	1.5
4	100	10.1	0.981	0.947	3.5

M_a =25 gm, r = 9cm					
Trial	m_b (gm)	w (rad/sec)	m_b (N)	$M_a r w^2$ (N)	Percentage Error(%)
1	25	10.68	0.245	0.257	4.9
2	50	14.14	0.491	0.450	8.35
3	75	17.91	0.736	0.721	2
4	100	20.42	0.981	0.938	4.4

M_a =25 gm, r = 8cm					
Trial	m_b (gm)	w (rad/sec)	m_b (N)	$M_a r w^2$ (N)	Percentage Error(%)
1	25	11.62	0.245	0.270	10.2
2	50	16.96	0.491	0.576	17.3
3	75	19.48	0.736	0.759	3.13
4	100	22.31	0.981	0.995	1.43

...ple of calculation

$m_a = 25\ g$, $r = 12.5\ cm$, $m_b = 25\ g$

$w = N * \frac{2\pi}{60} = (0.29 * 300)(\frac{2\pi}{60}) = 9.11\ rad/s$

$m_b g = (0.025)(9.81) = 0.245\ N$

$m_a r w^2 = (0.025)(0.125)(9.11)^2 = 0.258\ N$

$Error\ \% = \left|\frac{m_b g - m_a r w^2}{m_b g}\right| * 100\%$

$= \left|\frac{0.245 - 0.258}{0.245}\right| * 100\% = 5.3\%$

2) $m_a = 50$, $r = 12.5$, $m_b = 50\ g$

$W = N * \frac{2\pi}{60} = (0.28 * 300)(\frac{2\pi}{60}) = 8.8\ rad/s$

$m_b g = (0.05)(9.81) = 0.491\ N$

$m_a r w^2 = (0.05)(0.125)(8.8)^2$

$= 0.484$

$Error\ \% = \left|\frac{m_b g - m_a r^2 w}{m_b g}\right| * 100\%$

$= \left|\frac{0.491 - 0.484}{0.491}\right| * 100\% = 1.43\%$

3) $m_a = 75\ g$, $r = 12.5$, $m_b = 50\ g$

$W = (0.23)(300)(2\pi/60) = 7.23\ rad/s$

$m_b g = (50 \times 10^{-3})(9.81) = 0.491\ N$

$m_a r w^2 = (0.075)(0.125)(7.23)^2 = 0.49$

$Error\ \% = \left|\frac{m_b g - m_a r^2 w}{m_b g}\right| * 100\% = \left|\frac{0.491 - 0.49}{0.491}\right| * 100\%$

$= 0.203\%$

$m_a = 25\ g$, $m_b = 100$, $r = 9\ cm$

$w = (0.65 * 300)(2\pi/60) = 20.42\ rad/s$

$m_b g = (0.1)(9.81) = 0.981\ N$

$m_a r w^2 = (0.025)(0.09)(20.42)^2 = 0.938\ N$

$$Error\% = \left| \frac{m_b g - m_a r w^2}{m_b g} \right| * 100\%$$

$$= \left| \frac{0.981 - 0.938}{0.981} \right| * 100\% = 4.38\%$$

5) $m_a = 25\ g$, $m_b = 75\ g$ $r = 8\ cm$

$w = (0.62)(300)(2\pi/60) = 19.477\ rad/s$

$m_b g = (0.075)(9.81) = 0.736\ N$

$m_a r w^2 = (0.025)(0.08)(19.477)^2$

$= 0.759\ N$

$$Error\% = \left| \frac{m_b g - m_a r w^2}{m_b g} \right| * 100\%$$

$$= \left| \frac{0.736 - 0.759}{0.736} \right| * 100\%$$

$= 3.1\%$

fig 1 : Fc vs. mb , at : constant r=12.5 cm & variable ma

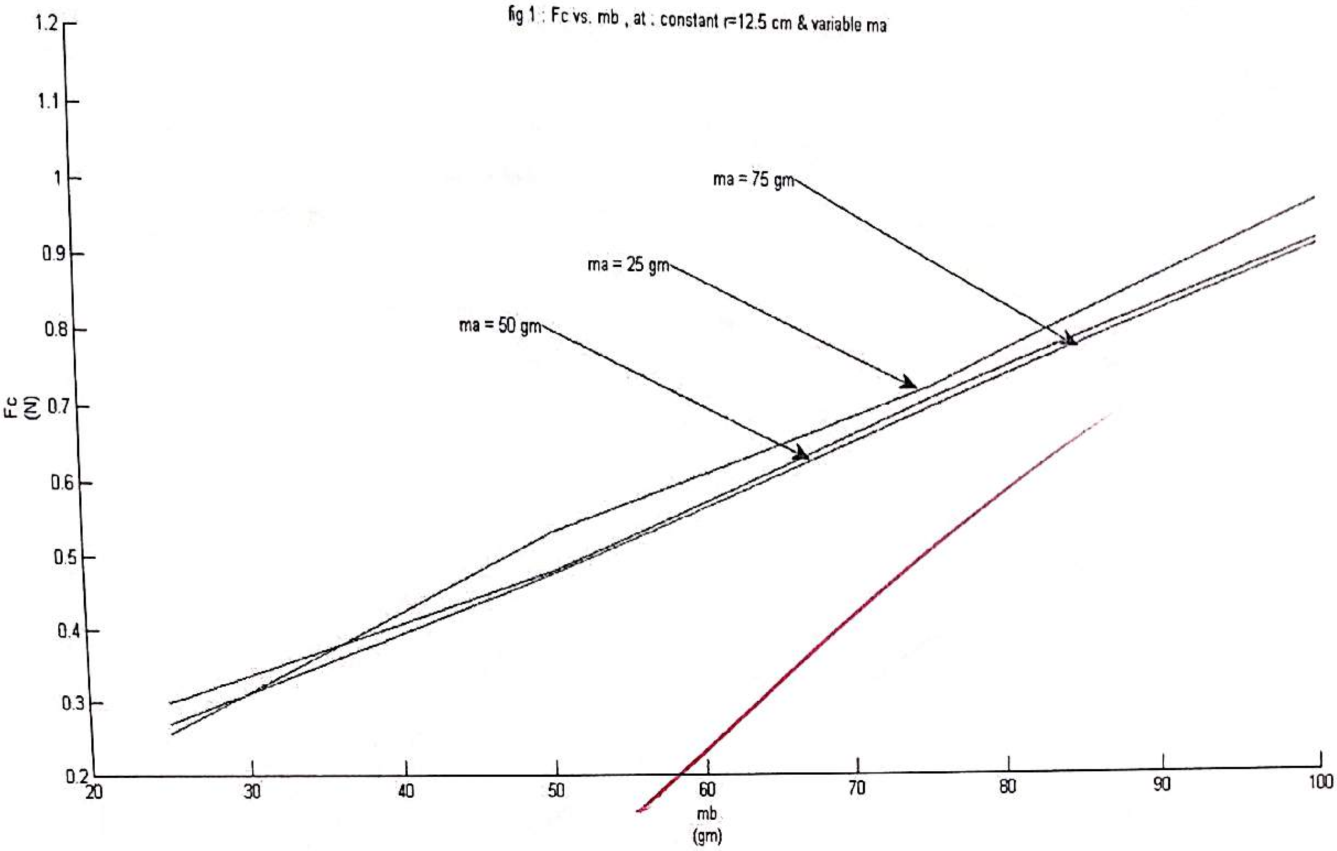
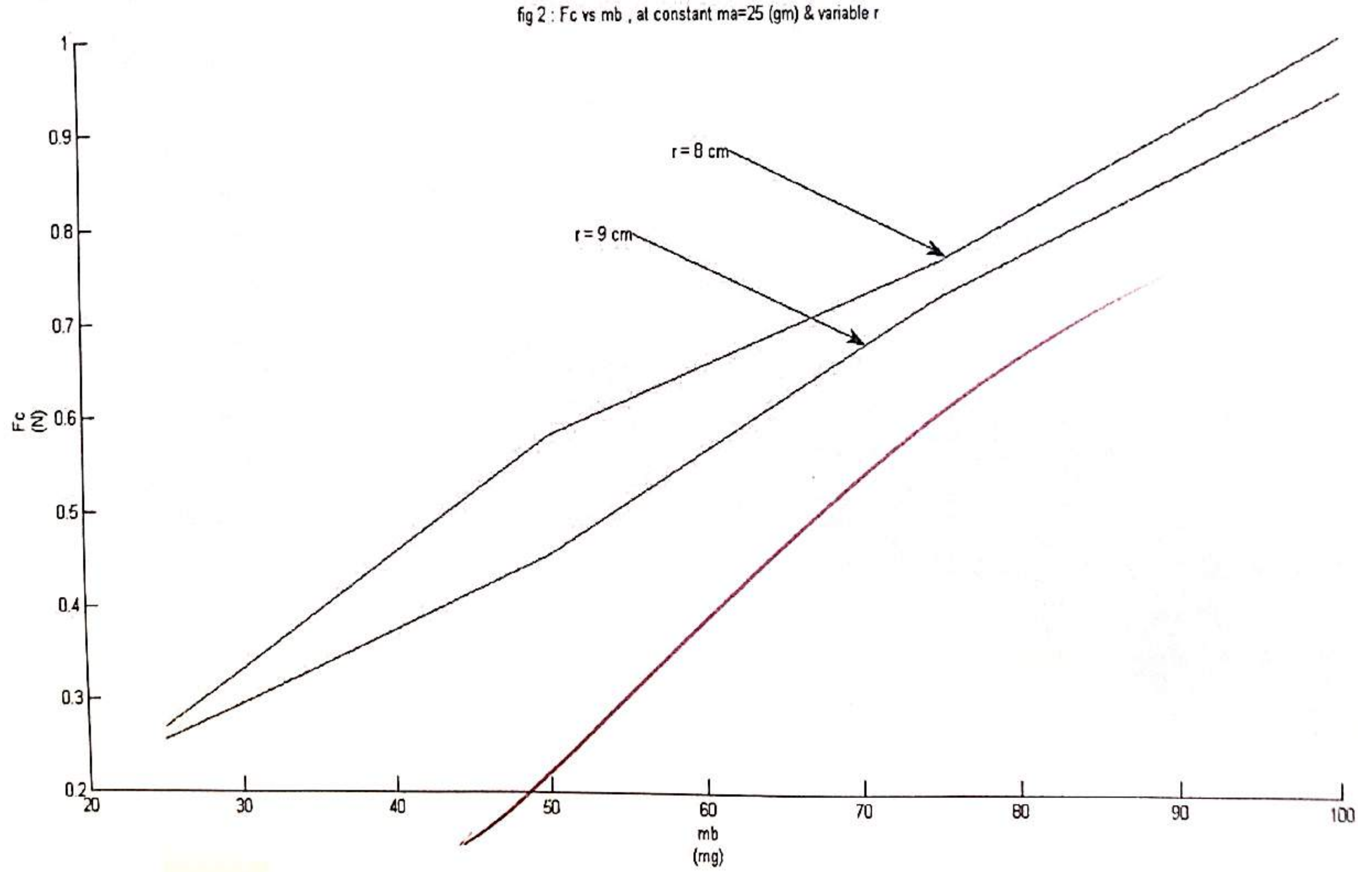


fig 2 : Fc vs mb , at constant ma=25 (gm) & variable r



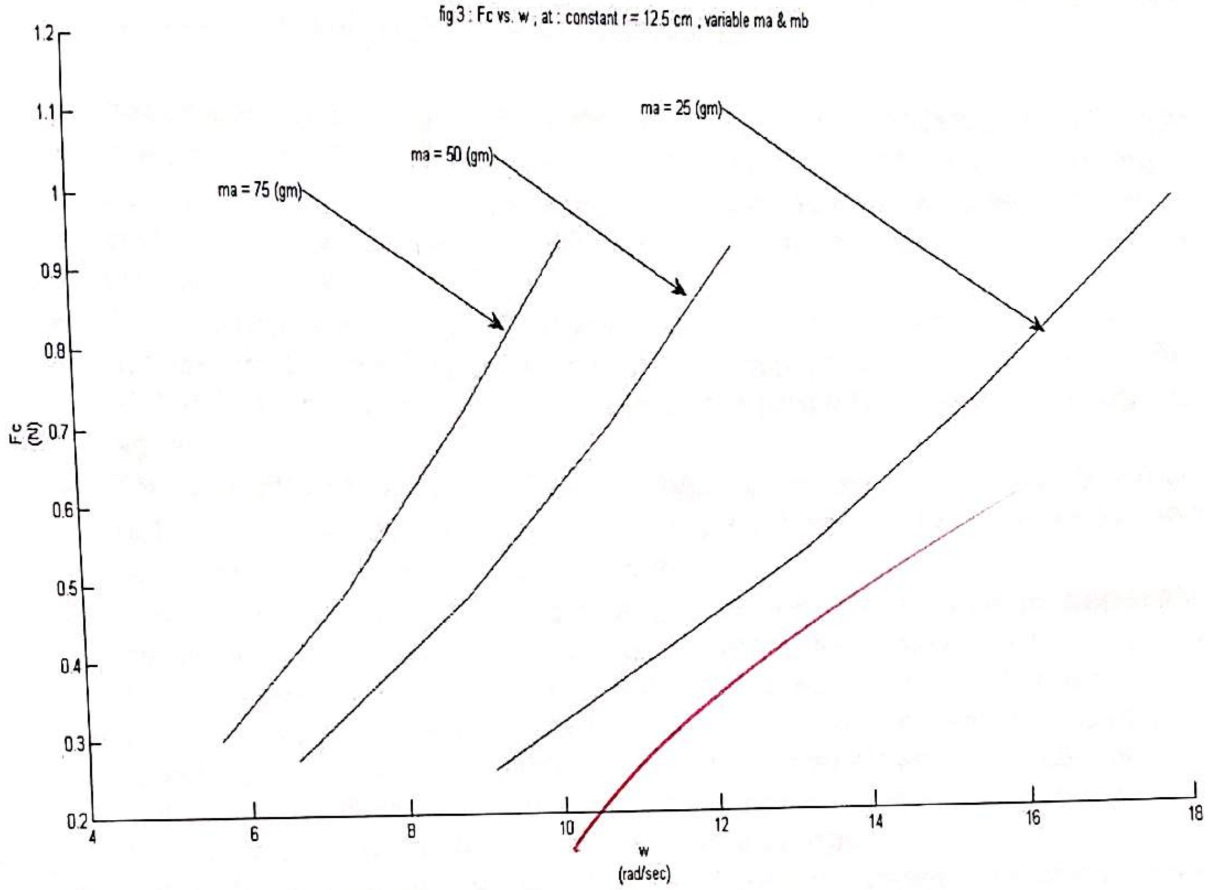


fig 3 : Fc vs. w , at : constant r = 12.5 cm , variable ma & mb
ma = 25 (gm)
ma = 50 (gm)
ma = 75 (gm)
Fc
(N)
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
4
6
8
10
12
14
16
18
w
(rad/sec)

1. **Give some typical examples in which the concept of the centrifugal force is employed in practical applications?**

- **Helicopter rotor systems** depend primarily on rotation to produce relative wind which develops the aerodynamic force required for flight. Because of its rotation and weight, the rotor system is subject to forces and moments peculiar to all rotating masses. One of the forces produced is *centrifugal force.*
- **The "loop the loop" feature** found on some roller coasters in amusement parks.There the track descends on a long slope and then, at the bottom, turns in a complete circle (drawing) before leveling out again.
- **The centrifugal force of Earth's rotation** causes its equator to bulge out, making the surface there more distant from the Earth´s center and thus weakening the gravitational pull.
- There are a multiplicity of applications of centrifugal force **to separate materials in a wide variety of methodologies**. There are many ways of expressing the desired sample preparation: sedimentation; concentration; isolation; purification; physical separation; layering; pelleting; filtration; washing; rinsing; measurement; deposition; combination; destructive testing; etc. However, they are all done with the application of centrifugal force upon a sample.
- **Centrifugal pumps** consist of a set of rotating vanes, enclosed within a housing or casing, used to impart energy to a fluid through centrifugal force.
- **In Turbines** ,the start locks are metal pins that are held out by centrifugal force at operating rpm, which allows the blade angle to change.

2. **What is the difference between centrifugal and centripetal force?**

Centripetal Force andCentrifugal Force, action-reaction force pair associated with circular motion. According to Newton's first law of motion, a moving body travels along a straight path with constant speed (i.e., has constant velocity) unless it is acted on by an outside force. For circular motion to occur there must be a constant force acting on a body, pushing it toward the center of the circular path. This force is the centripetal ("center-seeking") force. For a planet orbiting the sun, the force is gravitational; for an object twirled on a string, the force is mechanical.

According to Newton's third law of motion, for every action there is an equal and opposite reaction. The centripetal force, the action, is balanced by a reaction force, the centrifugal ("center-fleeing") force. The two forces are equal in magnitude and opposite in direction. The centrifugal force does not act on the body in motion; the only force acting on the body in motion is the centripetal force. The centrifugal force acts on the source of the centripetal force to displace it radially from the center of the path. Thus, in twirling a mass on a string, the centripetal force transmitted by the string pulls in on the mass to keep it in its circular path, while the centrifugal force transmitted by the string pulls outward on its point of attachment at the center of the path.

The centrifugal force is often mistakenly thought to cause a body to fly out of its circular path when it is released; rather, it is the removal of the centripetal force that allows the body to travel in a straight line as required by Newton's first law. If there were in fact a force acting to force the body out of its circular path, its path when released would not be the straight tangential course that is always observed.

When performing the experiment, you increase the speed of the motor slowly until you hear knocking sound where the spider turns over. At that instant, if you try reversing the process and returning to the original position, you will observe that it needs a large reduction in the speed of the motor, and not slight as in the forward one. Explain why?

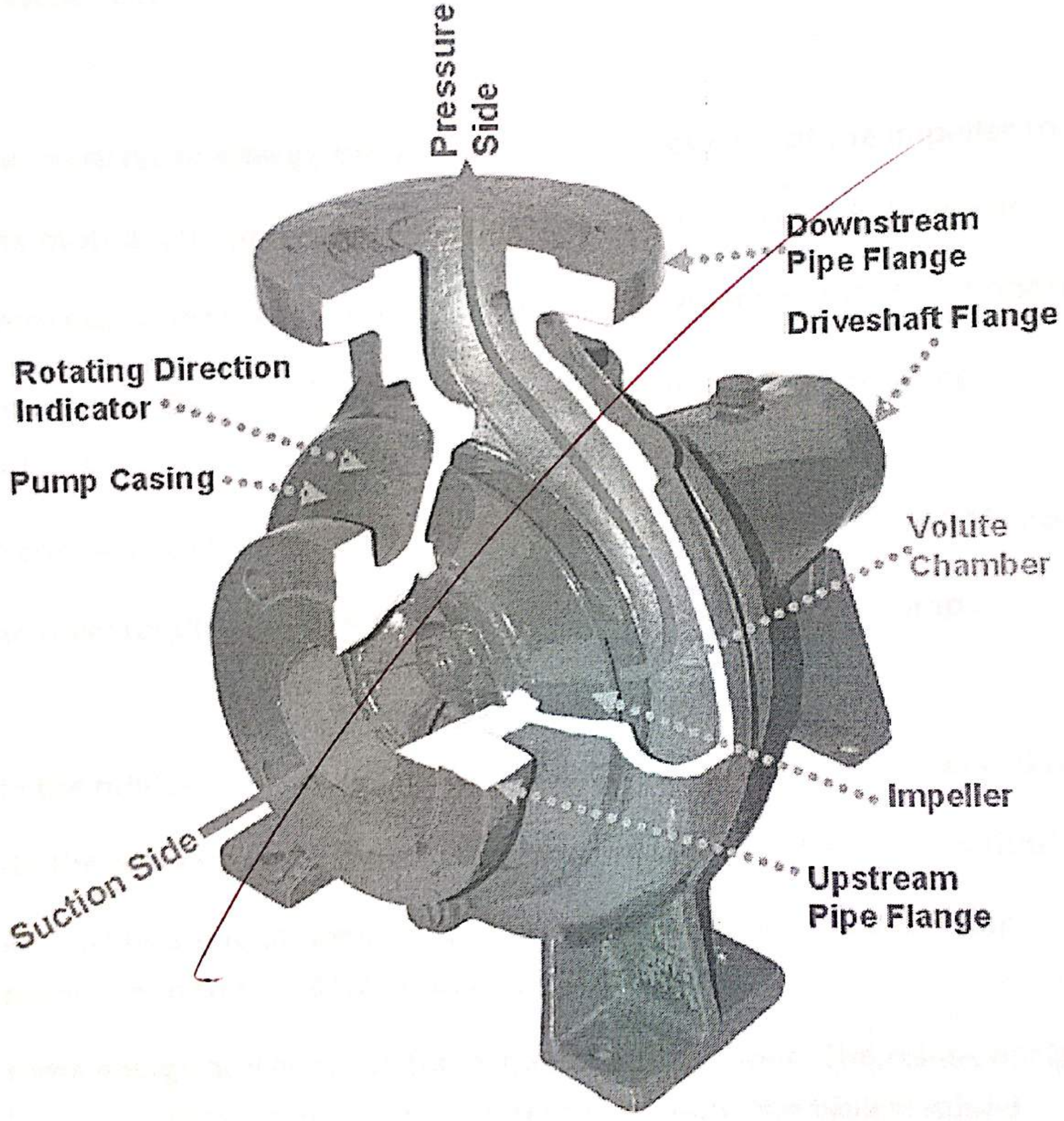
After knocking occurs, the mass m_b is located at an elevation. Reducing the speed of motor develops a centripetal force towards the centre opposing the centrifugal force. Thus mass m_b needs larger reduction to overcome the centrifugal force and the moment of mass m_a and return the set to its original position again.

3. **For Automobiles to move on circular paths safely, it is considered in their design to have a wide base and low height (*separation from ground*). Explain?**

By this design of low height, the arm radius of the centrifugal force that tries to push the automobile outside its path will be lesser and thus the resulting moment around vehicle's center of gravity **CG** that tires to rollover the vehicle will be reduced. In the other hand, having wider base means that the gravitation force of the vehicle weight will have a larger arm radius which means its moment around **CG** that counteracts the moment of centrifugal force will be larger and can overcome the moment of centrifugal force. This will ensure more car stability while moving on circular paths with the aid of suspension system and the friction forces from the ground on the tires. Huge vehicles such as lorries and buses that have relatively high separation from the ground should decrease the speed while rotating in order to avoid the rollover away from the path due to up-shifting drag force caused by centrifugal moment which tends to set the normal force of theground to zero and thus separating the inner wheels and canceling their frictional effect and the vehicle will lose stability and rollover!

Centrifugal pump :

How it works



Like most pumps, a centrifugal pumps converts mechanical energy from a motor to energy of a moving fluid; some of the energy goes into ،kinetic energy of fluid motion, and some into potential energy represented by a fluid pressure or by lifting the fluid against gravity to a higher leve

The transfer of energy from the mechanical rotation of the impeller to the motion and pressure of the fluid is usually described in terms of centrifugal force, especially in older sources written before the modern concept of *centrifugal force* as a fictitious force in a rotating reference

frame was well articulated. The concept of *centrifugal force* is not actually required to describe the action of the centrifugal pump .

In the modern centrifugal pump, most of the energy conversion is due .to the outward force that curved impeller blades impart on the fluid

Invariably, some of the energy also pushes the fluid into a circular motion, and this circular motion can also convey

some energy and increase the pressure at the outlet. The relationship between these mechanisms was described, with the typical mixed conception of centrifugal force as known as that time .