CENTRIPETAL ACCELERATION

OBJECTIVE

1. To calculate the net force on an object moving in Uniform Circular Motion (UCM) and compare to the expected value.
2. Graphically calculate the mass of the object moving in Uniform Circular Motion (UCM) and compare with expected value.

EQUIPMENT

1. centripetal force apparatus
2. set of masses and hanger
3. stopwatch
4. string
5. level
6. ruler

THEORY

A. Mass Rotating in Uniform Circular Motion

Consider the *Centripetal Force Apparatus* below. The mass M_{bob} is rotating in uniform circular motion about the vertical rod in a radius R.

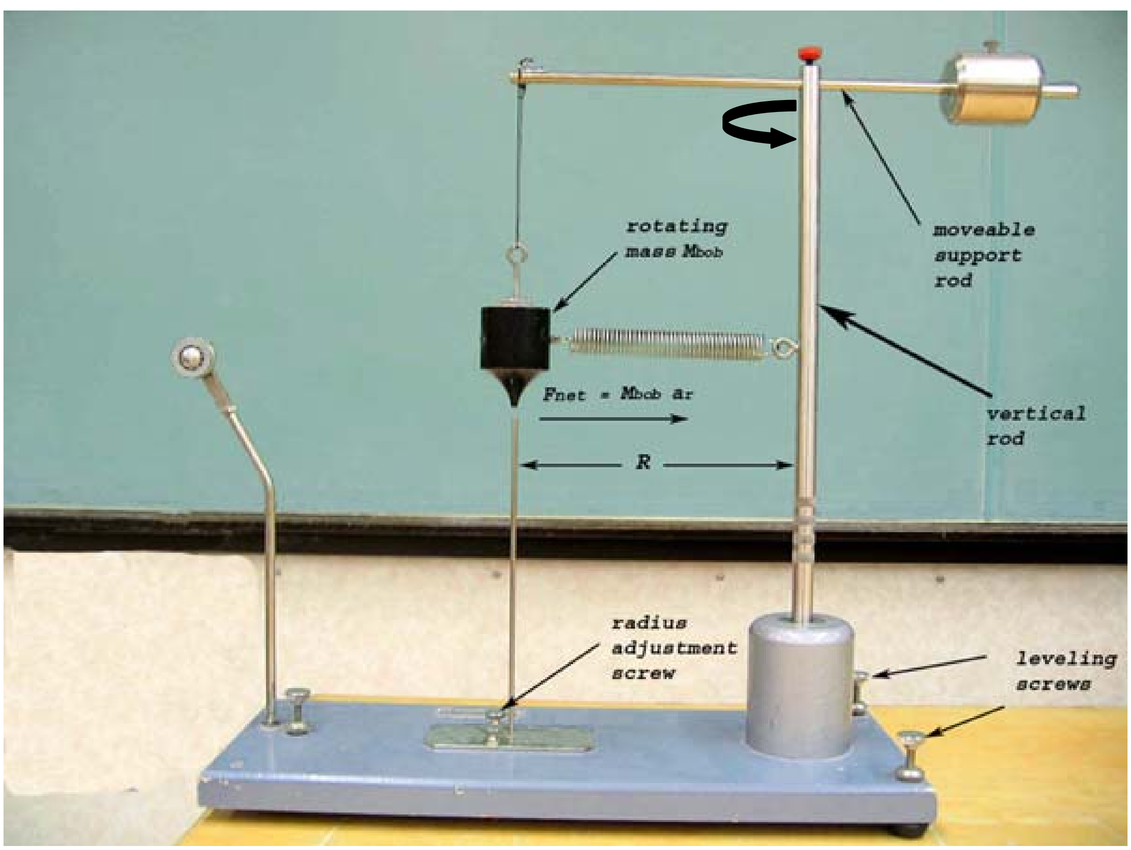
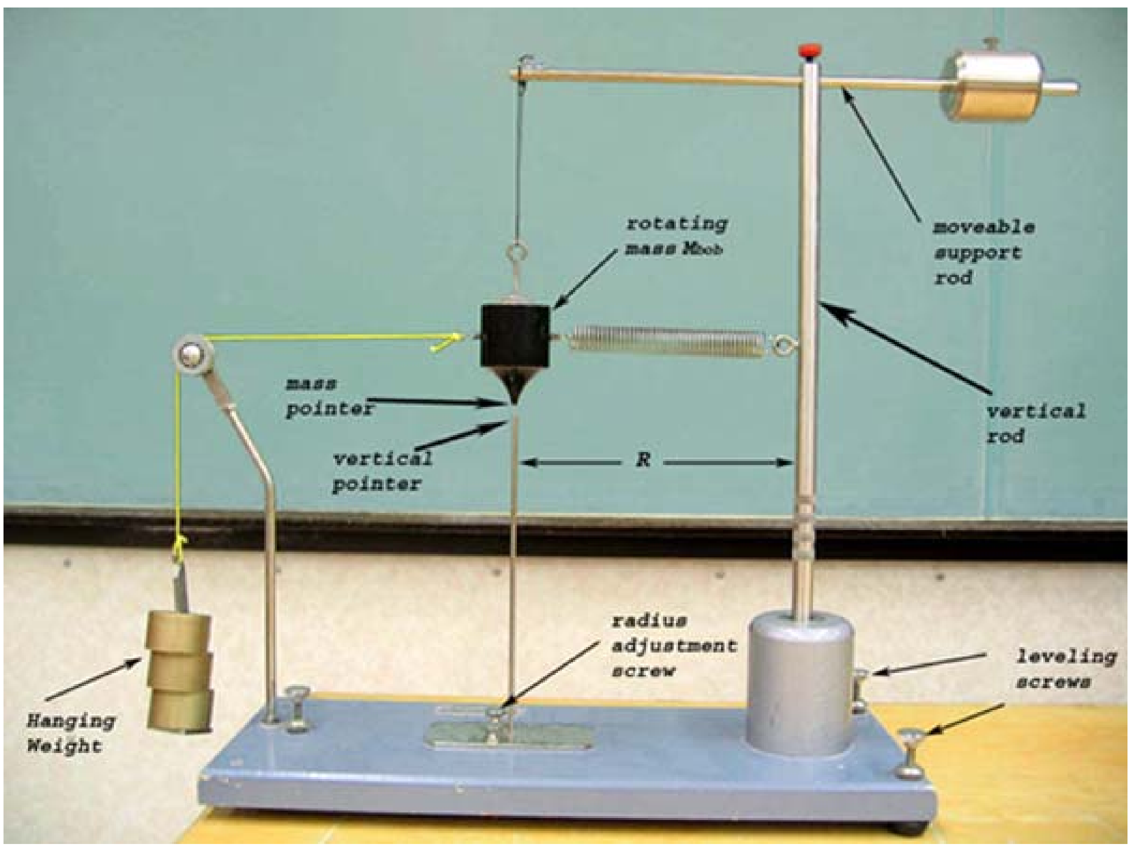


Diagram 1

Applying Newton's 2nd Law in the radial direction gives a net force in the radial direction given by $F_{net} = M_{bob} a_r$ where $a_r = \frac{v^2}{R}$. The speed of the mass M_{bob} is given by $v = \frac{2\pi R}{T}$ and thus $a_r = \frac{4\pi^2 R}{T^2}$. Therefore, $\boxed{F_{net} = M_{bob} \frac{4\pi^2 R}{T^2}}$.

B. <u>Mass in Equilibrium</u>

Now let's consider the case when the mass M_{bob} is in equilibrium and the radius *R* is the same as it was when it was rotating in uniform circular motion. If this is the case, then the tension force which equals the weight of the hanging mass $W_{hanging}$, must be equal to the net force in the radial direction $F_{net} = M_{bob} \frac{4\pi^2 R}{T^2}$ when the mass M_{bob} was rotating in uniform circular motion. We will be comparing these two values taking $W_{hanging}$ to be the expected value.



<u>Diagram 2</u>

PROCEDURE

Part 1(Uniform Circular Motion – Diagram 1)

1. Remove mass M_{bob} from apparatus and measure the mass with triple-beam balance. Place mass M_{bob} back on the apparatus - but do not attach spring
2. With the spring not attached, level the platform with the level and align the mass pointer with the vertical pointer.
3. Measure the radius R.
4. Attach spring to mass $M_{bob.}$
5. Rotate M_{bob} at constant speed so that bob pointer is aligned with the vertical pointer.
6. Measure the time for 20 revs 3 times and calculate the average period.
7. Calculate the radial acceleration a_r using the average period.
8. Calculate the net force F_{net}.

Part 2 (Static Equilibrium – Diagram 2)

1. Leave the spring attached to mass $M_{bob.}$
2. Attach string with hanger to mass $M_{bob.}$
3. Add mass to hanger until the mass pointer and vertical pointer are aligned just as it was when M_{bob} was rotating in uniform circular motion.
4. Calculate weight $W_{hanging}$ of hanging mass.
5. Compare $W_{hanging}$ with F_{net}. Take $W_{hanging}$ to be the accepted value and use $g = 9.80\ m/s^2$.
6. Repeat Part (1) and Part (2) above for a total of 4 different radii.

Construct a data table like the following in your lab report:

R (cm)	M_{bob}(kg)	t_1 (20 revs)	T_1(s)	t_2 (20 revs)	T_2(s)	t_3(20 revs)	T_3(s)	T_{ave}

R (cm)	a_r	F_r(N)	$M_{hanging}$(kg)	$W_{hanging}$(N)	%error

Part III. Determining M_{bob} Graphically

1. Using EXCEL construct a graph with appropriate axis that gives a linear curve whose slope is related to the mass of the bob M_{bob}.
2. Obtain the equation of the best curve-fit and determine M_{bob} from the slope of the curve.
3. Compare M_{bob} to its measured value.