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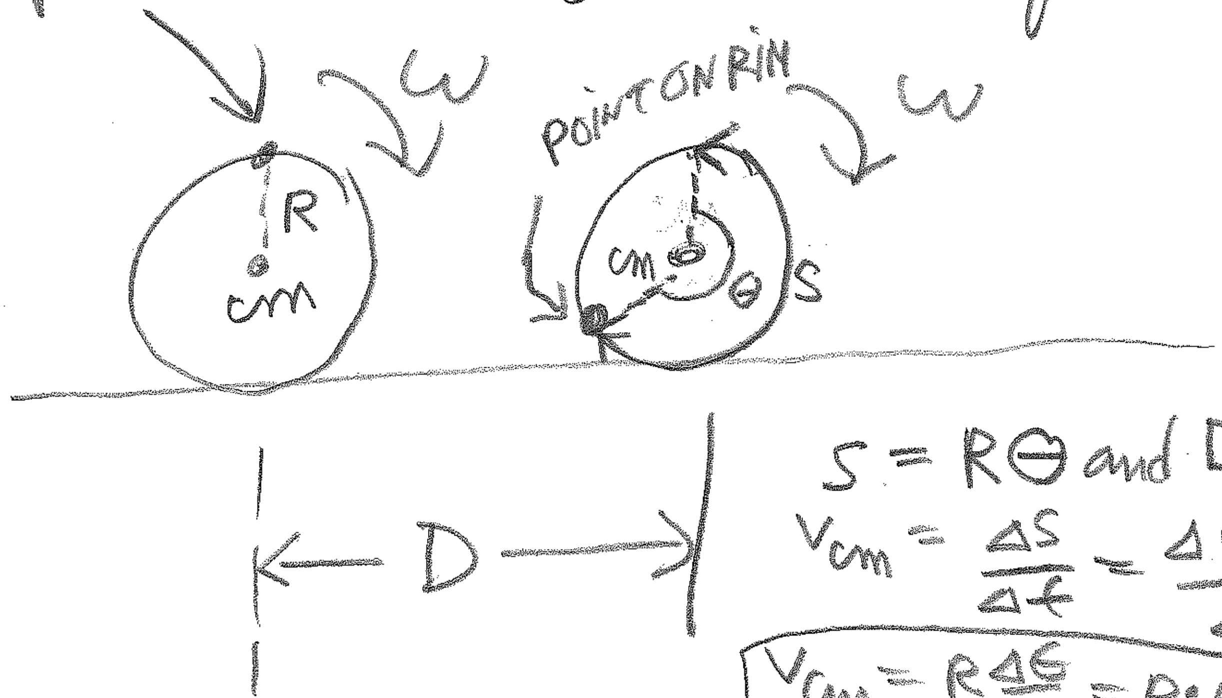
9.5 Rolling

CM = center of mass *

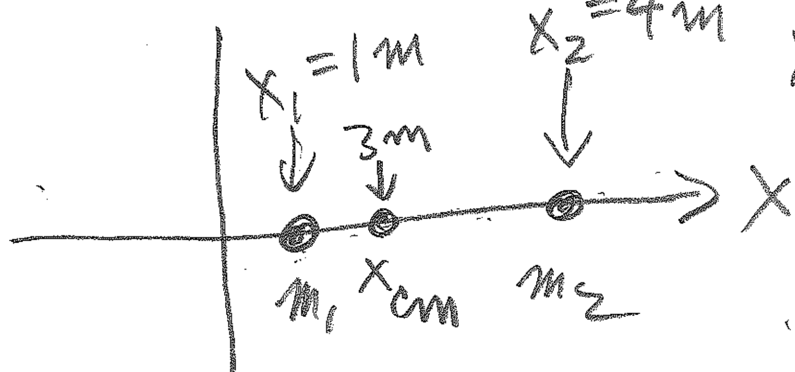


$S = R\theta$ and $D = S$

$v_{cm} = \frac{\Delta S}{\Delta t} = \frac{\Delta (R\theta)}{\Delta t}$

$$v_{cm} = R\frac{\Delta \theta}{\Delta t} = R \cdot \omega$$

* Balance point (CH 8) → ~~se~~ 8.6

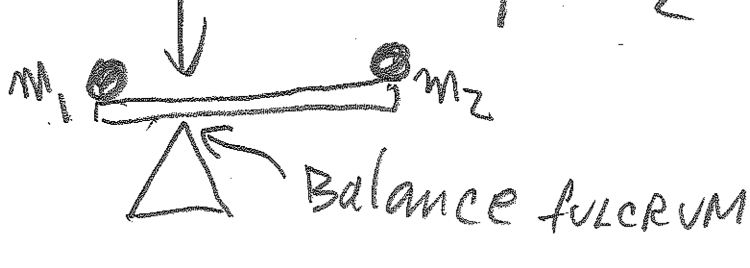


$$x_{cm} = \frac{m_1 x_1 + m_2 x_2}{m_1 + m_2}$$

$m_1 = 2kg$

$m_2 = 1kg$

$m_1 > m_2$



$$x_{cm} = \frac{(2kg)(1m) + (1kg)(4m)}{2kg + 1kg}$$

$= 3m$

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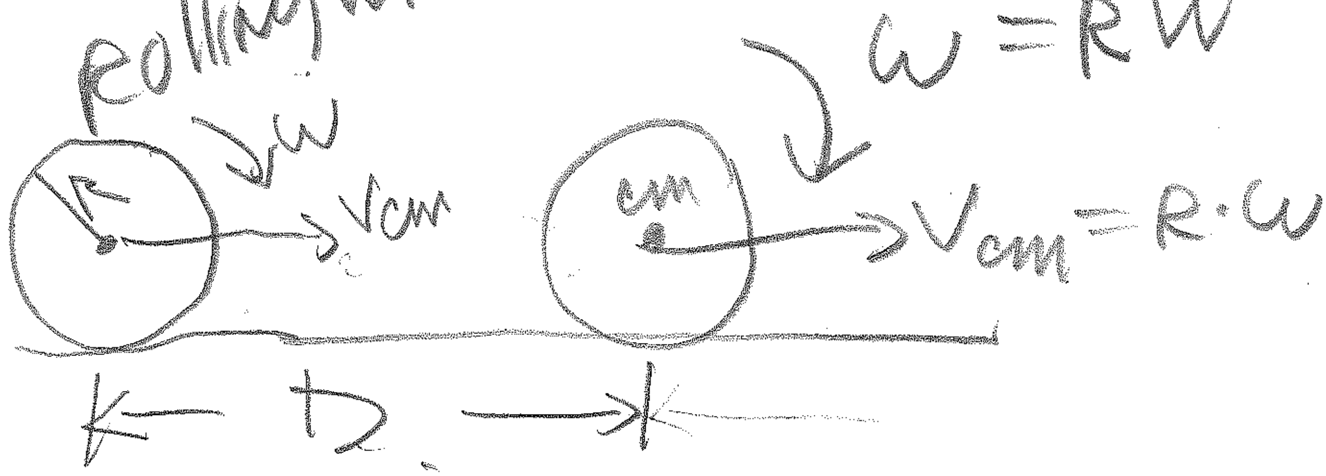
Rolling wheel (of your CAR)



Device in CAR

speedometer	odometer	tachometer
V_{cm}	D	ω

$$\text{Energy} = KE_{\text{Trans}} + KE_{\text{ROT}}$$

translation = Trans.

Rotation = ROT.

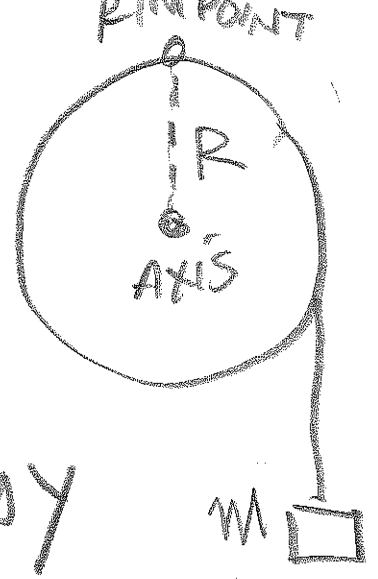
$$\text{Energy} = \frac{1}{2} M V_{cm}^2 + \frac{1}{2} I_{cm} \omega^2 ; \omega = \frac{V_{cm}}{R}$$

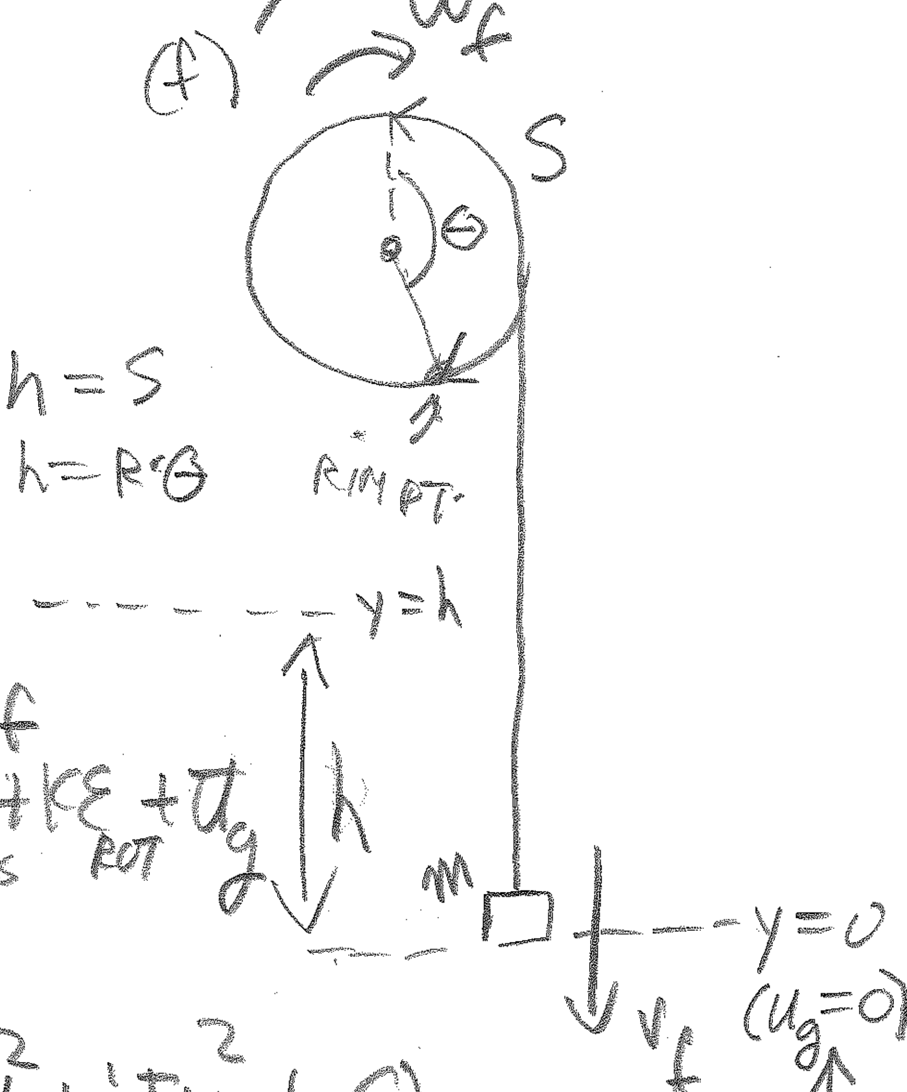
$$K_{\text{Trans}} + K_{\text{ROT}}.$$

(4R)

Use conservation of Energy

(i) AT REST





$U_g = mgy$

$\text{Energy}_i = \text{Energy}_f$

$KE_{TRANS} + KE_{ROT} + U_g = KE_{TRANS} + KE_{ROT} + U_g$

$0 + 0 + mgh = \frac{1}{2}mv_f^2 + \frac{1}{2}I\omega_f^2 + 0$

$mgy = 0$
$(y = 0)$

NOTE: $v_f = \omega_f \cdot R = R \cdot \omega_f$

v_f = LINEAR speed of RIM POINT.

$$\omega_f = \frac{v_f}{R}$$

$$mgh = \frac{1}{2} m v_f^2 + \frac{1}{2} I \cdot \frac{v_f^2}{R^2}$$

$$mgh = \frac{1}{2} m v_f^2 + \frac{1}{2} \cdot I \cdot \frac{v_f^2}{R^2}$$

$v_f = 3.5\ m/s$

$h = 2.5\ m$

$m = 3.00\ kg$

$R = 0.75\ m$

$$(3)(9.8)\cdot(2.5) = \frac{1}{2}(3)(3.5)^2 + \frac{1}{2} \cdot \frac{1}{2} M \cdot R^2 \cdot \frac{3.5^2}{R^2}$$

$$73.5 = 18.75 + \frac{1}{4} M \cdot 3.5^2$$

$$59.75 = \frac{1}{4} M \cdot 3.5^2$$

$$M = \frac{4 \cdot (59.75)}{3.5^2} = 19.5\ kg$$

$$I = \frac{1}{2}MR^2$$

$$= \frac{1}{2}(19.5)(0.75)^2$$

$$= 5.48\ kg \cdot m^2$$

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Centripetal Force

Reference---CH. 5

Objective - The basic purpose of this lab is to test whether the equation $F = mv^2 / r$ for uniform circular motion is correct.

Concepts - You should know that centripetal force is the name given to any force or sum of forces that causes a change in the direction of motion of an object to produce circular motion. In this experiment, you are testing Newton's 2nd Law for the case of uniform circular motion.

Computations--- You should be able to:

1. Calculate the theoretical value of the centripetal force m_1v^2/r from the measured value of the period of revolution, the radius of the path and the mass m_1 of the object.
2. Compute the measured value of the centripetal force F from m_2g, the weight of the hanging mass described in the procedure, and compare this result with the theoretical value.

EQUIPMENT

centripetal force apparatus (hand-operated)
weight set
string
weight balance
carpenter's level
meter stick

PROCEDURE

The experiment is based on ideas in the text and employs a manual centripetal force device. Following is a summary of the steps needed to complete the lab:

1. Level the base of the centripetal force apparatus. Turn knobs and use carpenter's level.
2. Find the mass m_1 of the bob using the mass balance. You may need to add extra COUNTER-weights since the mass of the bob exceeds the mass balance maximum.
3. Measure r, the radius of the circular motion.
4. Place the vertical pointer rod directly under the mass m_1 of the bob while mass m_1 is hanging freely. (i.e. no spring attached to the bob.)
5. Attach the spring to the bob m_1.
6. Rotate the shaft so that m_1,while rotating, stretches the spring and lines up with the vertical pointer.
7. Find the period of rotation by timing 10 revolutions. ($T = t/10$.) Practice this action before you actually take data.
8. Repeat the timing procedures 6 and 7 TEN more times.
9. Using the weight set, find the force required to stretch the spring the same amount as when m_1 was rotating.
10. Compare the force m_2g required to stretch the spring with m_1v^2/r .

	Trial 1	Trial 2	Trial 3
No of Revs			
Total time(s)			
Time/rev=T'	~1.125	✓	✓
	Trial 4	Trial 5	Trial 6
No of Revs			
Total time(s)			
Time/rev=T'	✓	✓	✓
	Trial 7	Trial 8	Trial 9
No of Revs			
Total time(s)			
Time/rev=T'	✓	✓	✓
	Trial 10	Trial 11	Trial 12
No of Revs			
Total time(s)			
Time/rev=T'	✓		

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M= ~0.460 kg (bob mass)

Radius = ~ 0.10 m TO 0.14 m = R

(~1.15) Average T' = $\frac{T_1' + T_2' + T_3' + T_4' + T_5' + T_6' + T_7' + T_8' + T_9' + T_{10}'}{10}$

T'_{AV} LEAVE BLANK

STDM= Each T'

Average speed of bob= $V_{AV} = \frac{2\pi R}{T'_{AV}} = 1\frac{m}{s}$ TO $2\frac{m}{s}$

mg = 2.5(N) TO 7(N)

measure centripetal force

THEORETICAL CENTRIPETAL FORCE= $M_{BOB} \cdot \frac{V_{AV}^2}{R}$

percent difference =

QUESTION 1) DO YOU FIND THE MEASURED CENTRIPETAL FORCE RANGE AND THE THEORETICAL CENTRIPETAL FORCE AGREE WITHIN EXPERIMENTAL ERROR? SHOW WORK; USE ADDITIONAL SHEETS

$$\frac{\left| \frac{M_{BOB} V_{AV}^2}{R} - mg \right|}{\left[\frac{\left(\frac{M_{BOB} V_{AV}^2}{R} + mg \right)}{2} \right]} \times 100\%$$

NOTES/ADDITIONS/COMMENTS

$\Delta m \approx 2g = 0.002\ kg$

$\Delta m \cdot g$

$$\left| mg - \frac{M_{BOB} \cdot V_{AV}^2}{R} \right| < STDM + \Delta(mg)$$

$$\frac{STD}{\sqrt{10}} + 0.02\,(N)$$

STDM = standard deviation of mean of the 10 measurements of $\frac{MV^2}{R}$

Example trial 1, $T_1' = 1.12(s)$

$$V_1 = \frac{2\pi R}{1.12(s)} \Rightarrow \frac{MV_1^2}{R}.$$

Use Excel { compute this 9 more times for trial 2, 3, 4 ... 10; you get 10 numbers. Find STDM of the 10 numbers: $STDM = \frac{STD}{\sqrt{10}}$