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ME 274 Lecture 25

Particle Kinetics – Angular Impulse Momentum – Part 2

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03/13/26

Housekeeping/Announcements

***Reminder for Henny to wear a mic during the lecture.

1. **HW 24 (4.Q and 4.S^R) due today!!**
2. Office hours are changing to ME2008B...
 - Second floor of renovated side of ME.
3. Bonus quiz grade at end of the semester if we get a good response rate to QR code surveys at the end of lecture.
 - If you are unable to attend lecture on that day/forget to fill it out:
 - Feel free to give feedback based on the content of that lecture's slides.
 - Way of you reviewing previous content and giving feedback to me.

Kinetics: Four-step problem solving method

1. FBDs:

- Draw appropriate FBD(s).
- Choose your coordinate system.

2. Kinetics:

- Choose what solution method for the particular problem at hand (**we will go over these in the coming days...**):
 - Newton/Euler (lectures 15-18) – **Analyzing an instant in time**
 - Work/Energy (lectures 19-20) – **Analyzing speed in terms of position**
 - Linear impulse/momentum (lectures 21-22) - **Analyzing change in velocity during a change in time**
 - Central Impact (lecture 23) - **Analyze velocities between two states**
 - **Angular impulse/momentum – (lectures 24-25) – Analyze Angular Velocity during a change in time**

3. Kinematics:

- Perform needed kinematic analysis (position/velocity/acceleration)
- Equations from step 2 will guide you in deciding what kinematics are needed for the solution of the problem

4. Solve:

- Count the number of equations/unknowns. *If you do not have enough equations to solve for unknowns:*
 - a) Draw more FBDs
 - b) You will need to do more kinematic analysis

Angular Impulse Momentum (AIM) - Overview

$$\int_1^2 \Sigma \vec{M}_O dt = \left(\sum_i (\vec{H}_O)_i \right)_2 - \left(\sum_i (\vec{H}_O)_i \right)_1$$

Where:

- $(\vec{H}_O)_i = \vec{r}_{i/O} \times (m_i \vec{v}_i)$ is angular impulse momentum of particle P about a fixed-point O

1. AIM equation relates the ***change in time to change in angular momentum***

2. For ***central force problems*** all forces on the particle pass **through it**, $\mathbf{M}_O = \mathbf{0}$.
Therefore, angular momentum **is conserved**.

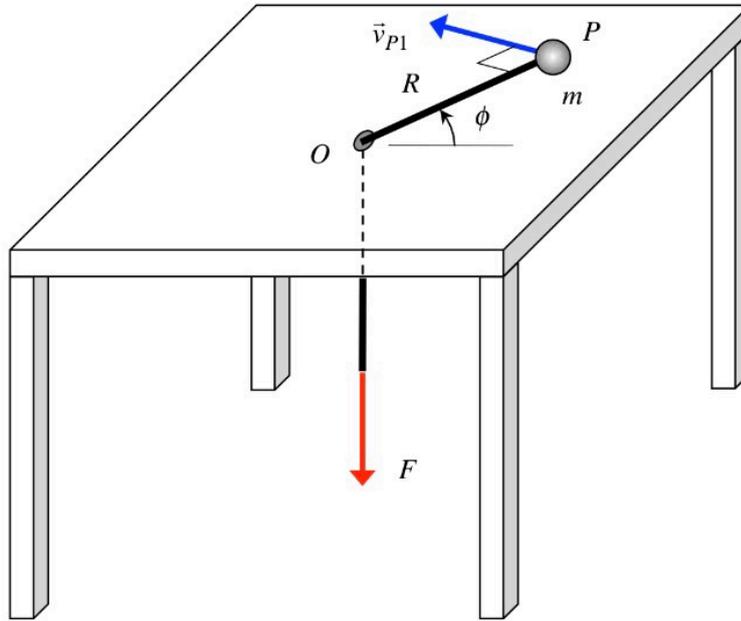
3. Angular momentum gives information of velocity in the **theta component**.

- If we want the **entire velocity vector** (+ radial component of velocity) we usually use the **Work-Energy Equation** for this.

Homework H4.R

Given: Particle P, having a mass of m , is able to slide on the smooth, horizontal top of a table. A flexible cable is attached to P, with the cable being fed through a hole in the table at O. A constant force F acts on the other end of the cable. The system is released with P being at a radial distance $R = R_1$ from O, and with P having a velocity perpendicular to OP with a speed of v_{P1} .

Find: Determine the numerical values for \dot{R} and $\dot{\phi}$ when P has moved to a position for which $R = R_2$.



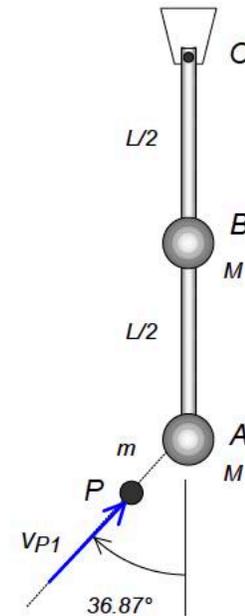
Use the following parameters in your analysis: $m = 3$ kg, $R_1 = 1.5$ m, $R_2 = 0.5$ m, $v_{P1} = 8$ m/s and $F = 2000$ N.

Example 4.D.5

Given: Particles A and B (each having a mass of M) are attached to rigid bar OA (this bar has negligible mass). Bar OA is pinned to ground at end O. This system is at rest when A is struck by a bullet P (having a mass of m) with the bullet traveling in the direction shown with a speed of v_{P1} . Immediately upon impact, the bullet becomes embedded in particle A.

Find: Determine the angular velocity of bar OA immediately after the collision is completed.

Use the following parameters in your analysis: $M = 2$ kg, $m = 0.1$ kg, $L = 3$ m and $v_{P1} = 700$ m/s.



Example 4.D.5

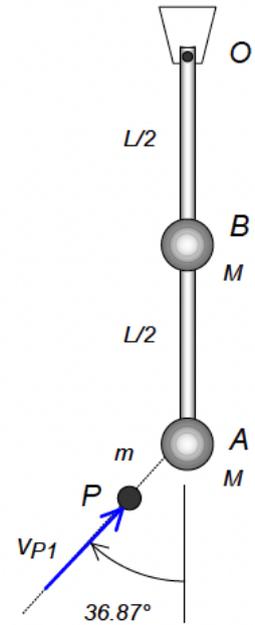
p.262

Similar to H.4.P

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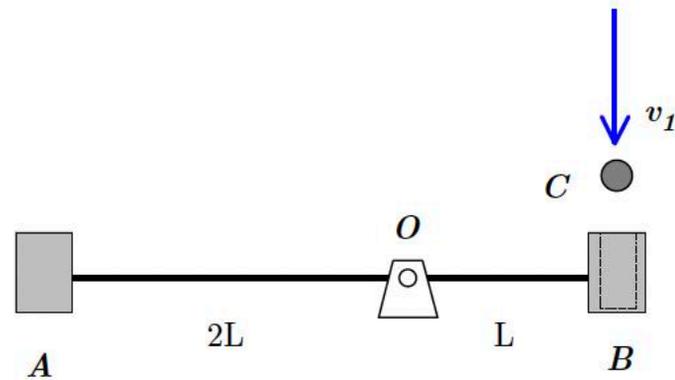
Use the following parameters in your analysis: $M = 2$ kg, $m = 0.1$ kg, $L = 3$ m and $v_{P1} = 700$ m/s.



Example 4.D.6

Given: Particles A and B, of masses $4m$ and $2m$, respectively, are attached to the ends a stationary rigid rod of negligible mass. The rod is pinned to ground at O. A third particle C, of mass m , strikes particle B with a speed of v_1 . On impact, C sticks to B. The system lies in the horizontal plane.

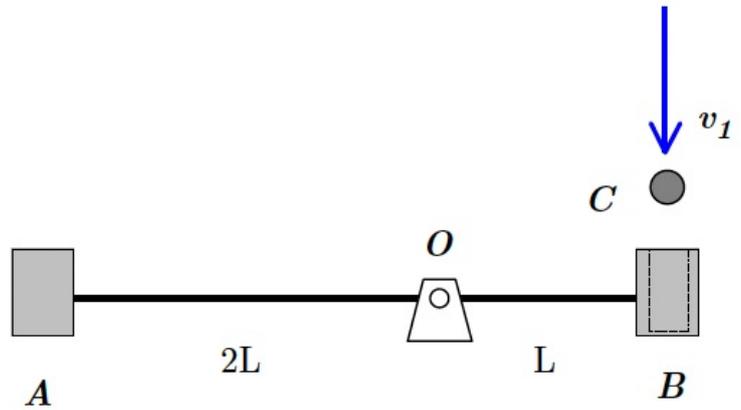
Find: Determine the angular speed of the bar immediately after the impact occurs.



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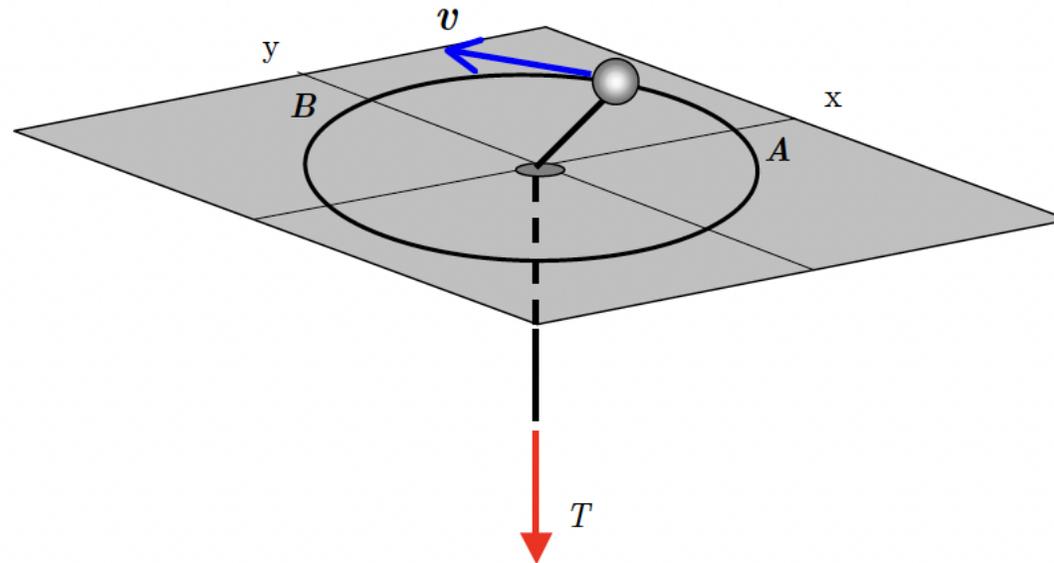


Example 4.D.7

Given: A particle of mass m is attached to a cord with the particle being able to slide on a smooth horizontal table top. This cord is pulled through a hole in the table top at O with a force of T being applied to the free end of the cord. The path of the particle is known to follow a path given by: $x^2/9 + y^2/36 = 1$. The speed of the particle at position A known to be v_A .

Find: Determine the force T when the particle is at position B .

Use the following parameters in your analysis: $m = 2\text{kg}$ and $v_A = 10\text{ m/s}$.

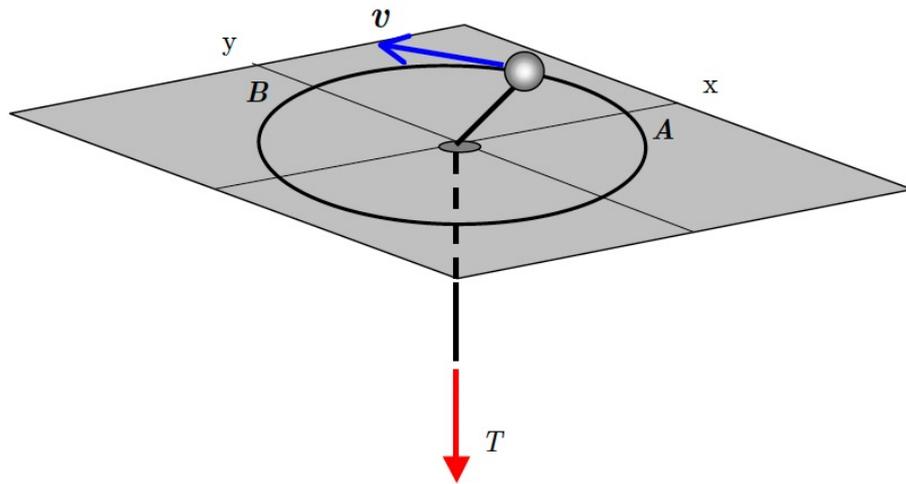


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Summary: Angular impulse/momentum equation 2

FUNDAMENTAL equation:

$$(\vec{H}_O)_2 = (\vec{H}_O)_1 + \int_1^2 \sum \vec{M}_O dt$$

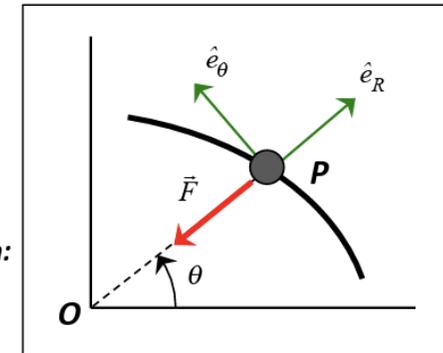
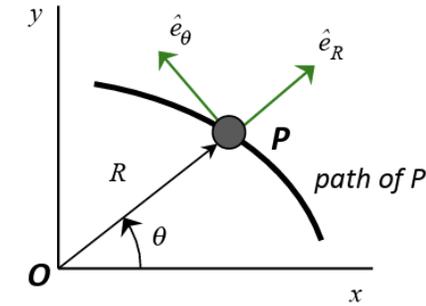
where O is a FIXED point.

WHEN should I use this equation? Think central-force problems... When $\sum \vec{M}_O = \vec{0}$, angular momentum about O is conserved.

IMPORTANT: This equation can NOT give information on the *radial* component of velocity for the particle. Why?

Why is this important?

Look at the above equation for computing angular momentum. Typically, use work/energy for the additional equation.



*central force problem:
force F acts directly
toward point O*

Lec 25 Short
Feedback Form:

