

Panel 1

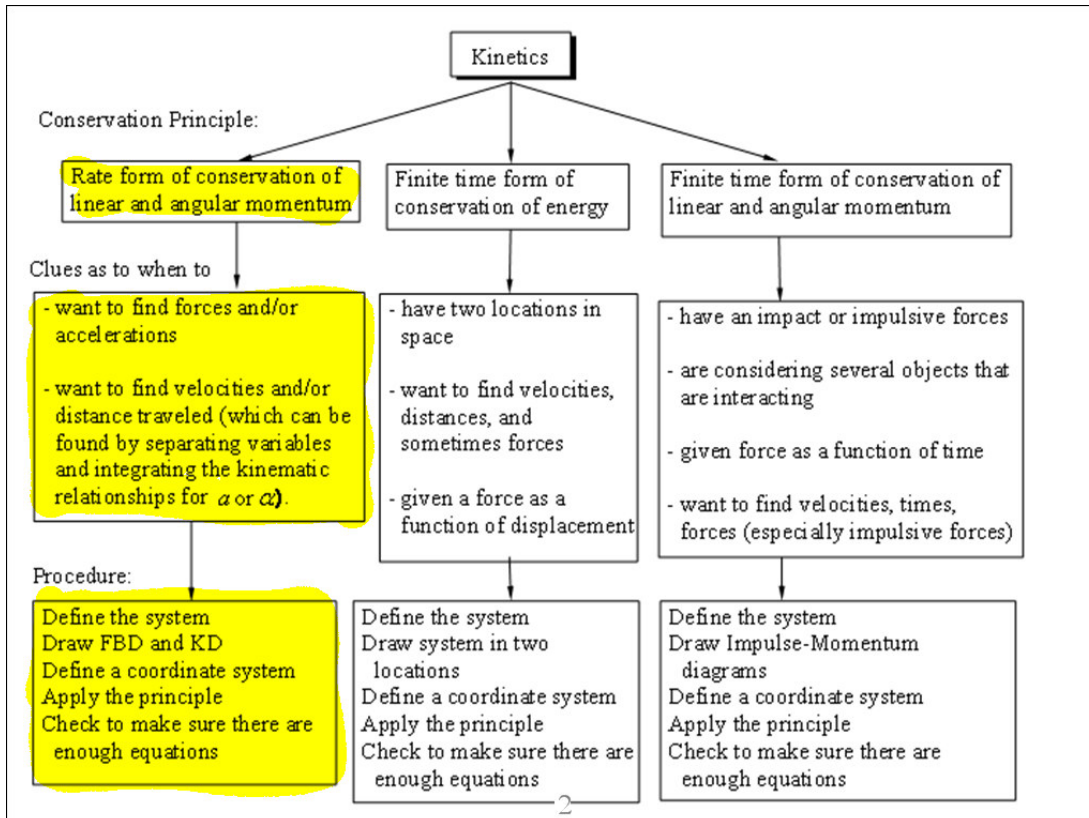
# ES204 Mechanical Systems

## GPM - Rolling Kinetics Lecture 23

Dr. Fisher

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Panel 2



Panel 3

## Rigid Body Motion Matrix


	Kinematics	CoLM CoAM Rate	Energy	CoLM CoAM Finite
Translation	Le10	Le10	✓	✓
Fixed Axis Rotation	Le11	Le12	Le12	Le13
General Plane Motion	Le14 Le15	Le22 Le23	Le16	Le19 Le20

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Panel 4

## Additional notes on kinetics


Rolling, no sliding:



Rolling, sliding impending:



Rolling and sliding:



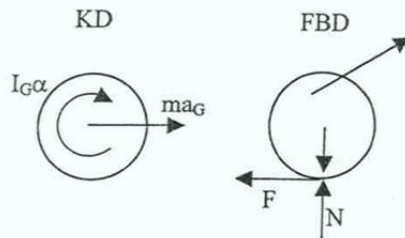
Rolling motion (for an object that has a radius  $r$  and a center of gravity located at the geometric center

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Panel 5

See if you were paying attention.

**Rolling motion** (for an object that has a radius  $r$  and a center of gravity located at the geometric center)

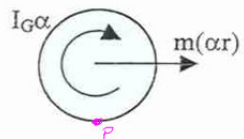


Rolling, no sliding:	$a_G =$	$F =$
Rolling, sliding impending:	$a_G =$	$F =$
Rotating and sliding:	$a_G =$	$F =$

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Panel 6

Generic KD for rolling without slip



Note:

$$\frac{dL_{sys}}{dt} = \sum M_o$$

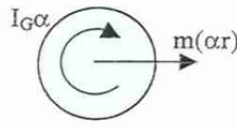
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Panel 7

**Remember:**  
If  $M$  and  $\alpha$  are in the same direction then you can determine the direction for  $\alpha$  based on knowing the direction of  $M$

**Demonstration – what direction does the spool roll? Label each one with either:**

Generic KD for rolling without slip



Note:

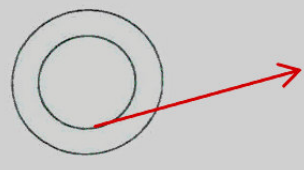
**A. It rolls Left**

**B. It rolls Right**

**C. It doesn't roll**

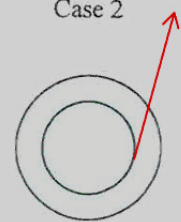
FBDs

Case 1



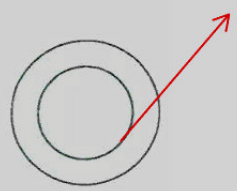
Case 1: \_\_\_\_\_

Case 2



Case 2: \_\_\_\_\_

Case 3

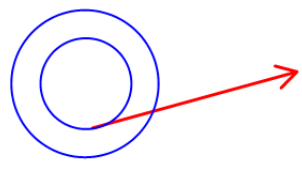


Case 3: \_\_\_\_\_

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Panel 8

**Case 1**



**A. It rolls Left**

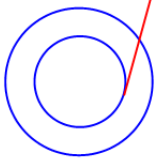
**B. It rolls Right**

**C. It doesn't roll**

C

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Panel 9

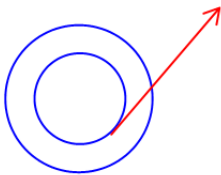
**Case 2**

- A. It rolls Left**
- B. It rolls Right**
- C. It doesn't roll**



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Panel 10

**Case 3**

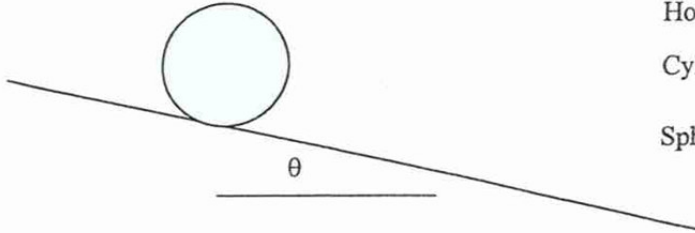
- A. It rolls Left**
- B. It rolls Right**
- C. It doesn't roll**



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Panel 11

**Demonstration 2 - Who will win the race?**

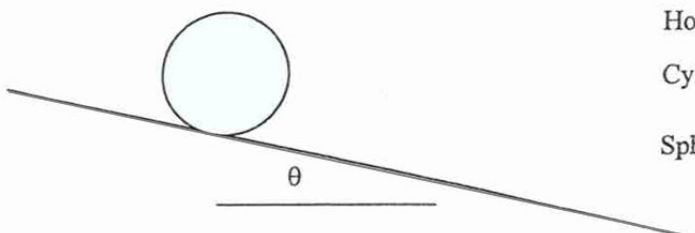


Hoop:  $I_G = mr^2$   
 Cylinder:  $I_G = \frac{1}{2}mr^2$   
 Sphere:  $I_G = \frac{2}{5}mr^2$

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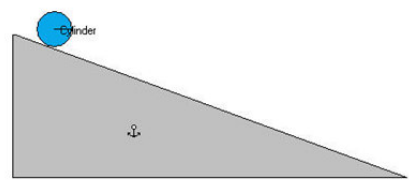
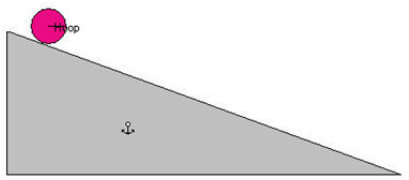
Panel 12

**Demonstration 2 - Who will win the race?**

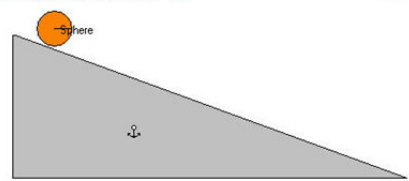
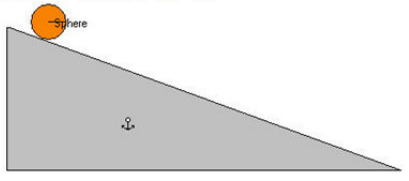


Hoop:  $I_G = mr^2$   
 Cylinder:  $I_G = \frac{1}{2}mr^2$   
 Sphere:  $I_G = \frac{2}{5}mr^2$

**A. Cylinder of mass m**      **B. Hoop of mass m**

**C. Sphere of mass m**      **D. Sphere of mass 10\*m**

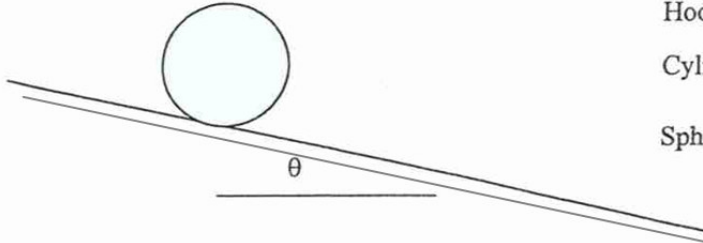



**E. A tie between the spheres**      **F. A tie between all 4**

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Panel 13

**Demonstration 2 - Who will win the race?**



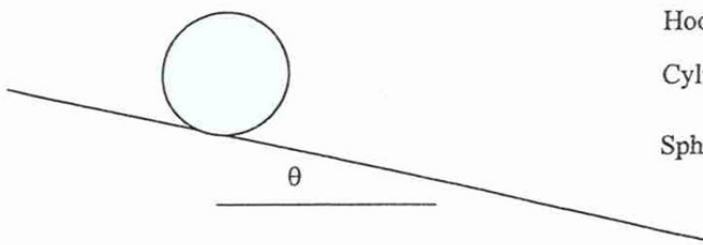
Hoop:  $I_G = mr^2$   
 Cylinder:  $I_G = \frac{1}{2}mr^2$   
 Sphere:  $I_G = \frac{2}{5}mr^2$

A. Cylinder of mass  $m$   
 B. Hoop of mass  $m$   
 C. Sphere of mass  $m$   
 D. Sphere of mass  $10*m$   
 E. A tie between the spheres  
 F. A tie between all 4

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Panel 14

**Demonstration 2 - Who will win the race?**



Hoop:  $I_G = mr^2$   
 Cylinder:  $I_G = \frac{1}{2}mr^2$   
 Sphere:  $I_G = \frac{2}{5}mr^2$

**First Place: Sphere (regardless of mass)**

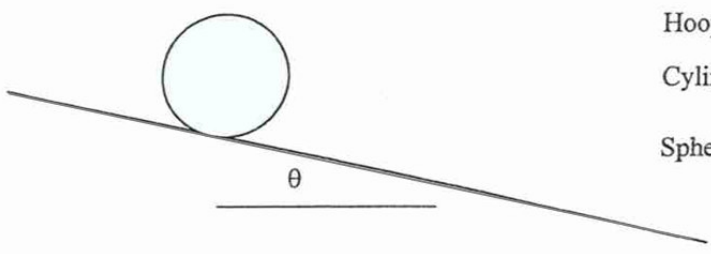
Second Place: Cylinder

Third Place: Hoop

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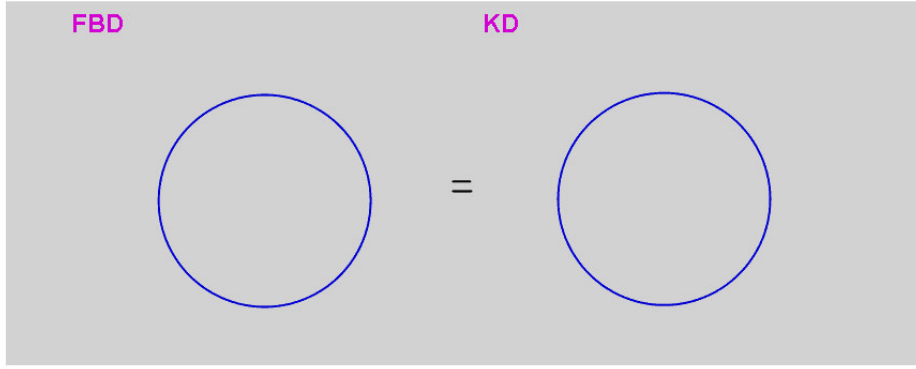
Panel 15

**Demonstration 2 - Who will win the race?**



Hoop:  $I_G = mr^2$   
 Cylinder:  $I_G = \frac{1}{2}mr^2$   
 Sphere:  $I_G = \frac{2}{5}mr^2$

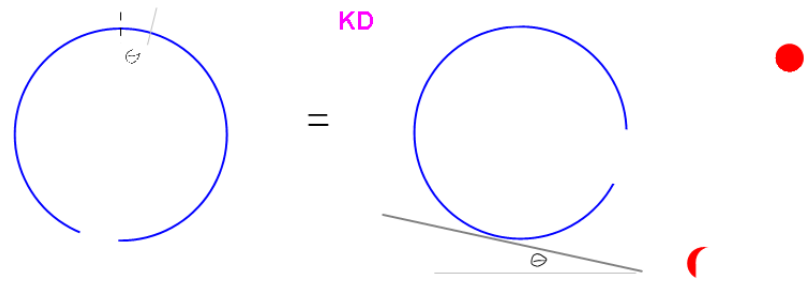
**FBD**                      **KD**



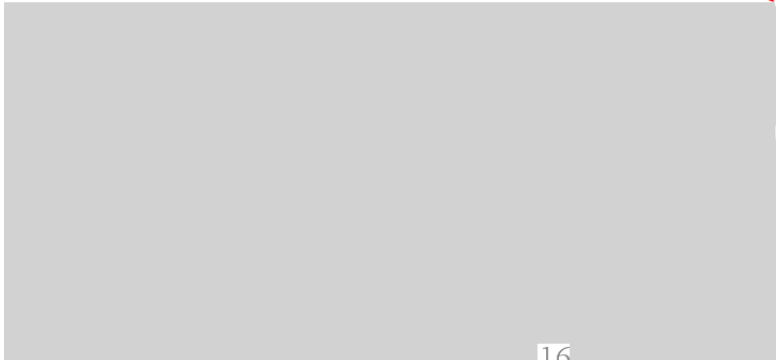
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Panel 16

**FBD**                      **KD**



**CoAM Rate equation (that gets rid of N and F)**  
**Solve it for  $a_g$  (Hint: Put alpha in terms of  $a_g$  to solve)**

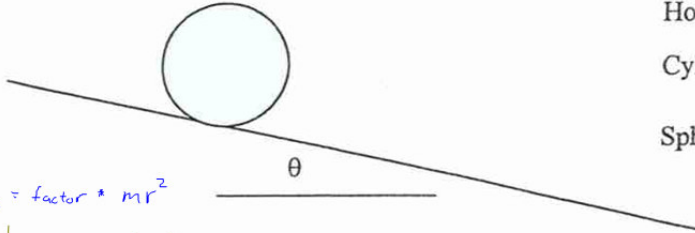


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Panel 17

**Demonstration 2 - Who will win the race?**



Hoop:  $I_G = mr^2$   
 Cylinder:  $I_G = \frac{1}{2}mr^2$   
 Sphere:  $I_G = \frac{2}{5}mr^2$

$I_G = \text{factor} * mr^2$   
 $a_g = \frac{1}{1+\text{factor}} g \sin \theta$

**First Place: Sphere** (regardless of mass)

Second Place: Cylinder

Third Place: Hoop

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