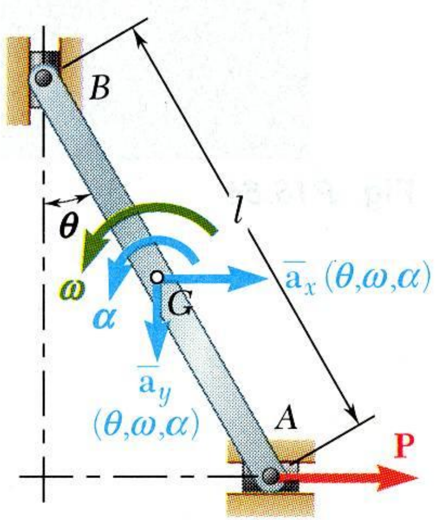
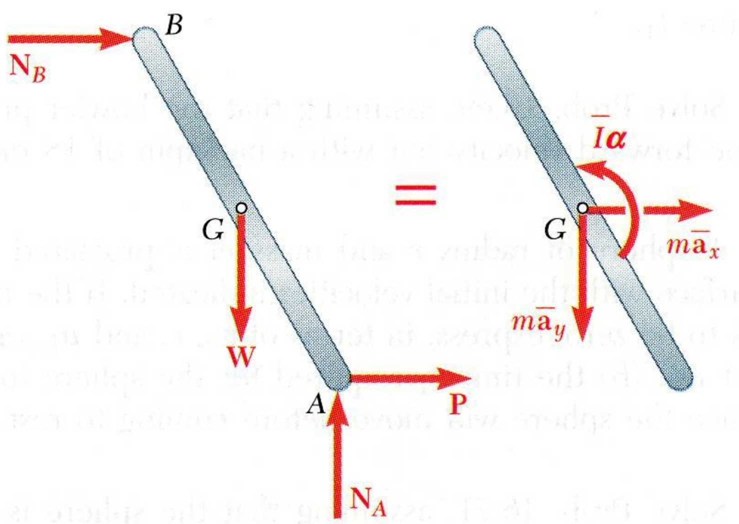
Preview of 16.7- 16.9

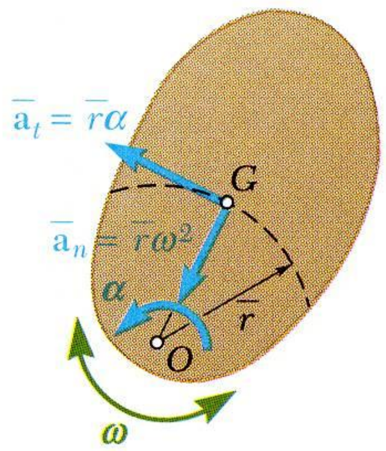
16.7 Constrained Plane Motion

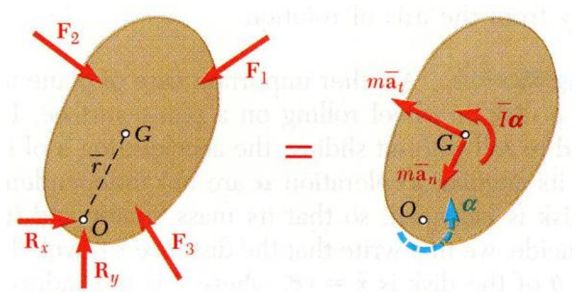


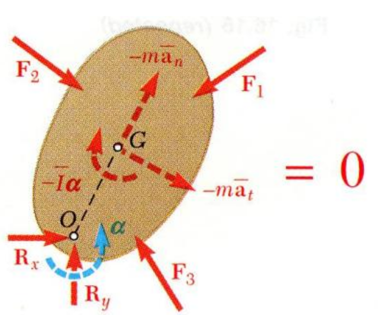


- Most engineering applications involve rigid bodies which are moving under given constraints, e.g., cranks, connecting rods, and non-slipping wheels.
- *Constrained plane motion*: motions with definite relations between the components of acceleration of the mass center and the angular acceleration of the body.
- Solution of a problem involving constrained plane motion begins with a kinematic analysis.
- e.g., given θ, ω, and α, find P, N_A, and N_B.
  - kinematic analysis yields $\bar{a}_x$ and $\bar{a}_y$.
  - application of d'Alembert's principle yields P, N_A, and N_B.

16.8 Constrained Motion: Noncentroidal Rotation





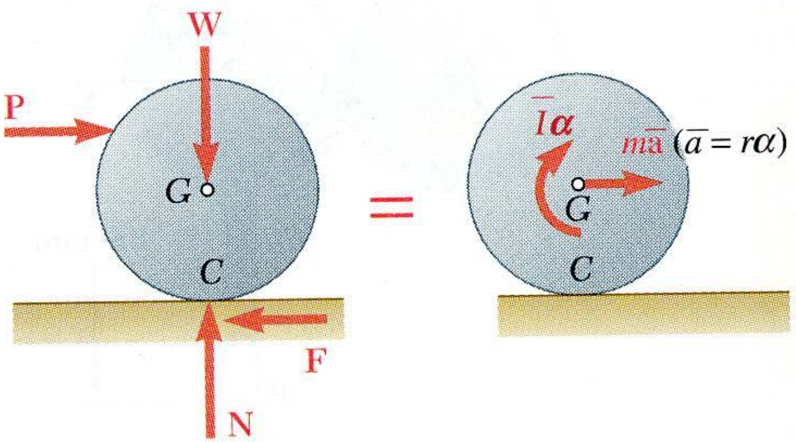


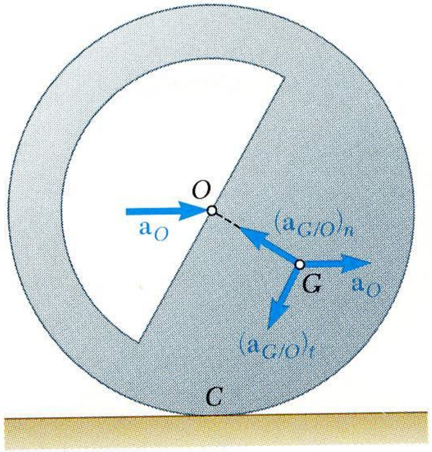
- *Noncentroidal rotation*: motion of a body is constrained to rotate about a fixed axis that does not pass through its mass center.
- Kinematic relation between the motion of the mass center *G* and the motion of the body about *G*,

$$\bar{a}_t = \bar{r}\alpha \qquad \bar{a}_n = \bar{r}\omega^2$$

- The kinematic relations are used to eliminate $\bar{a}_t$ and $\bar{a}_n$ from equations derived from d'Alembert's principle or from the method of dynamic equilibrium.
- Equate the moment about O:
- Motion with constant angular speed?

16.8 Constrained Plane Motion: Rolling Motion

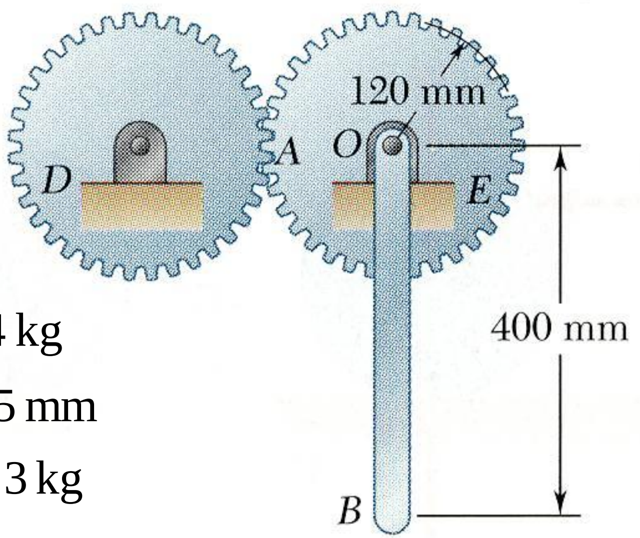




- For a balanced disk constrained to roll without sliding,
  $\bar{x} = r\theta \quad \rightarrow \quad \bar{a} = r\alpha$
- Rolling, no sliding:
  $F \leq \mu_s N \qquad \bar{a} = r\alpha$
  Rolling, sliding impending:
  $F = \mu_s N \qquad \bar{a} = r\alpha$
  Rotating and sliding:
  $F = \mu_k N \qquad \bar{a}, r\alpha$ independent
- For the geometric center of an unbalanced disk,
  $a_O = r\alpha$

  The acceleration of the mass center,
  $\vec{a}_G = \vec{a}_O + \square$
  $= \vec{a}_O + \square$

Sample Problem 16.6



$m_E = 4\text{ kg}$

$\bar{k}_E = 85\text{ mm}$

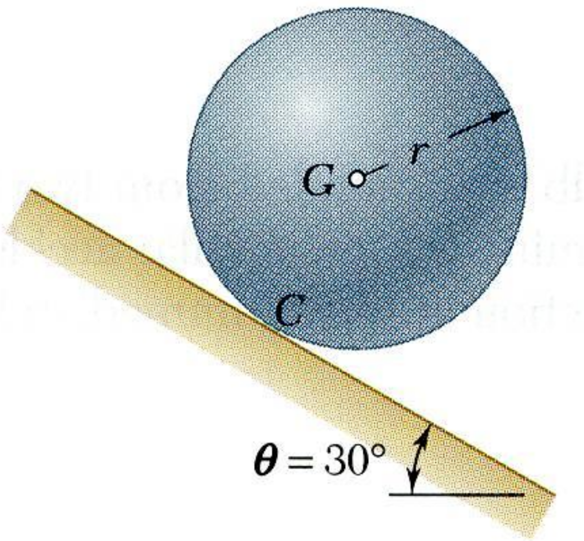
$m_{OB} = 3\text{ kg}$

The portion *AOB* of the mechanism is actuated by gear *D* and at the instant shown has a clockwise angular velocity of 8 rad/s and a counterclockwise angular acceleration of 40 rad/s^2.

Determine: a) tangential force exerted by gear *D*, and b) components of the reaction at shaft *O*.

Sample Problem 16.6

Sample Problem 16.8

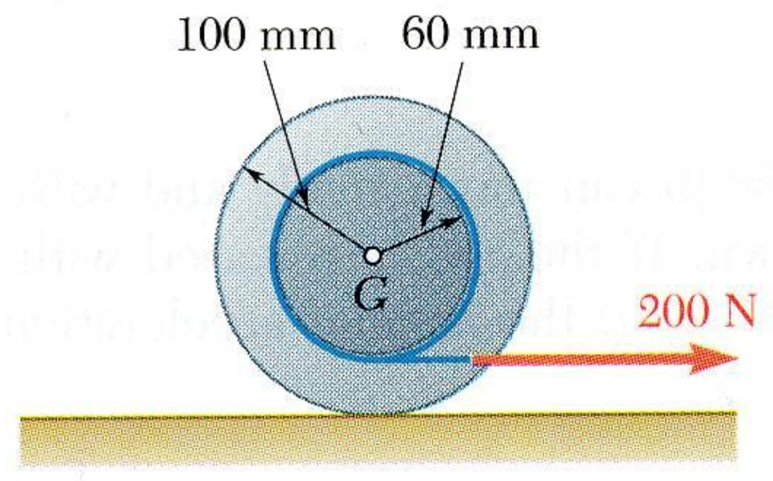


A sphere of weight W is released with no initial velocity and rolls without slipping on the incline.

Determine: *a*) the minimum value of the coefficient of friction, *b*) the velocity of G after the sphere has rolled 10 m and *c*) the velocity of G if the sphere were to move 10 m down a frictionless incline.

Sample Problem 16.8

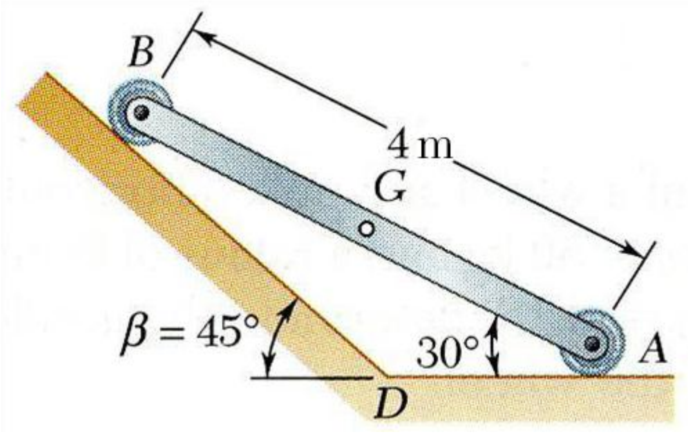
Sample Problem 16.9



A cord is wrapped around the inner hub of a wheel and pulled horizontally with a force of 200 N. The wheel has a mass of 50 kg and a radius of gyration of 70 mm. Knowing $\mu_s = 0.20$ and $\mu_k = 0.15$, determine the acceleration of G and the angular acceleration of the wheel.

Sample Problem 16.9

Sample Problem 16.10



The extremities of a 4-m rod weighing 50 N can move freely and with no friction along two straight tracks. The rod is released with no velocity from the position shown.

Determine: *a*) the angular acceleration of the rod, and *b*) the reactions at *A* and *B*.

Sample Problem 16.10