MECH 343 Theory of Machines I

Time: _ _ W _ _17:45 - 20:15

Lecture 12

Example

- A has constant velocity 12.6ft/s. mechanism moves in horizontal plane. M_3 and IG_3 are 2.2lb and 0.0479in.lb.s^2
- Find F_A required for dynamic equilibrium. M_2 and M_2 assume to be negligible and neglect friction
- Draw velocity polygon to get $V_{B/A}$ and then find the $A^n_{B/A}$ with ω_3 from which complete the acceleration polygon kowing the direction of $A^t_{B/A}$ and A_B
- From A_B, A_G can be scaled as 444ft/s^2 and

$$\alpha_3 = \frac{A^t_{BA}}{R_{BA}} = \frac{(713\ \text{ft/s}^2)(12\ \text{in/ft})}{10\ \text{in}} = 856\ \text{rad/s}^2\ \text{cw.}$$

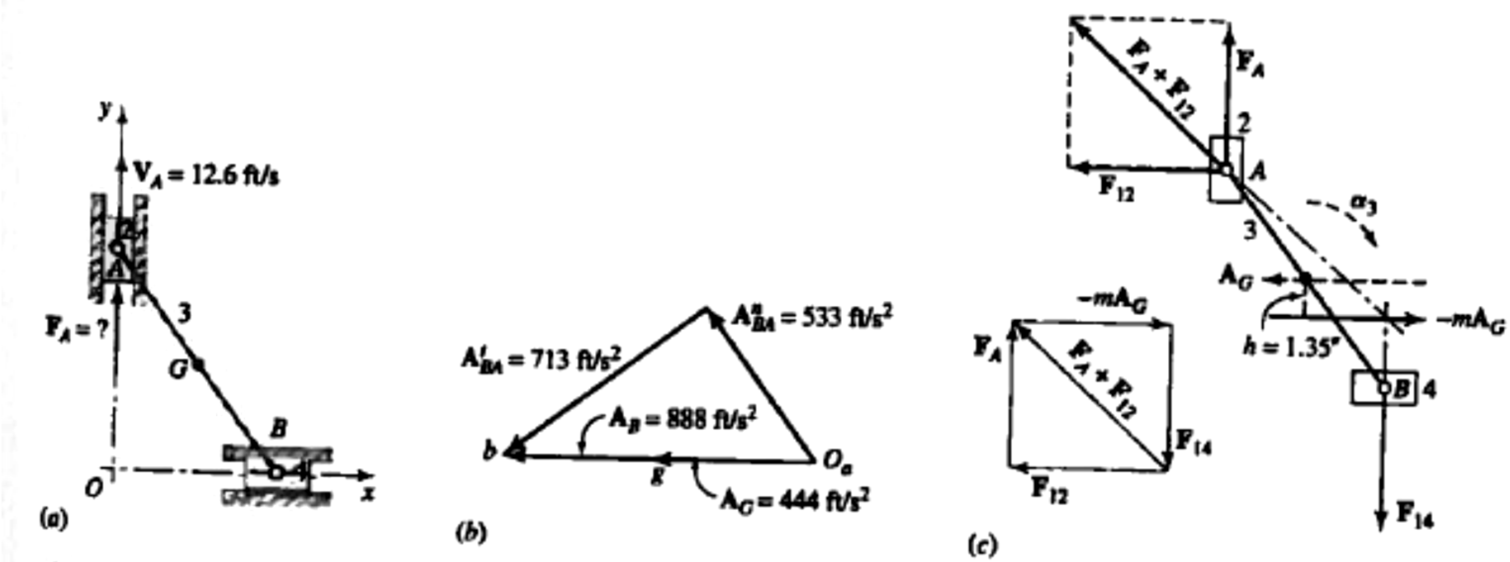

Figure 14.8 Solution for Example 14.3. (*a*) Scale drawing with $R_{BA} = 10$ in, $R_{GA} = 5$ in, $R_{AO} = 8$ in, and $R_{BO} = 6$ in. (*b*) Acceleration polygon. (*c*) Free-body diagram and force polygon.

Example

- Knowing M_3 and IG_3 are 2.2lb and 0.0479in.lb.s^2 h can be found

$$h = \frac{(0.0479\ \text{in} \cdot \text{lb} \cdot \text{s}^2)(856\ \text{rad/s}^2)}{(0.00570\ \text{lb} \cdot \text{s}^2/\text{in})(444\ \text{ft/s}^2)(12\ \text{in/ft})} = 1.35\ \text{in}$$

- Drawing the FBD we can analyze this to find F_A
- F_{14} is the vertical reaction force and F_{12} is the horizontal reaction force. F_{12} should be equal and opposite to mA_G
- mA_G is offset by h from G. using this LOA of $F_A + F_{12}$ can be found using point of concurrence of F_{14} and $-mA_G$
- F_A is found to be 27lb

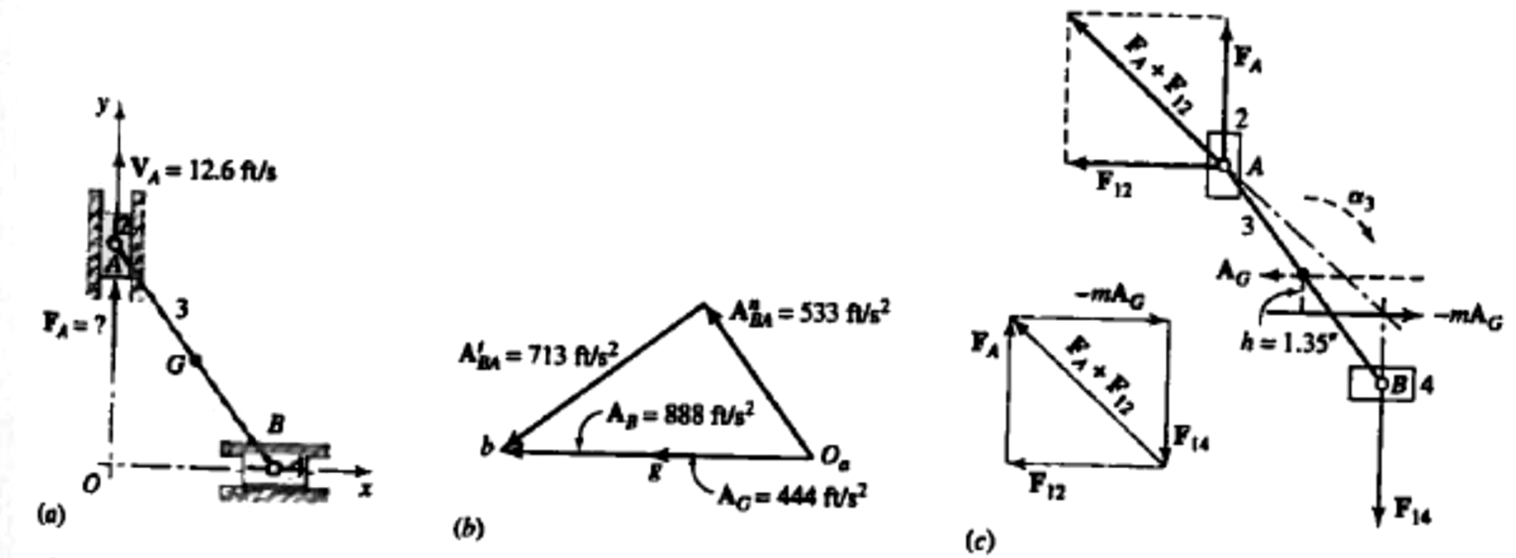

Figure 14.8 Solution for Example 14.3. (a) Scale drawing with $R_{BA} = 10$ in, $R_{GA} = 5$ in, $R_{AO} = 8$ in, and $R_{BO} = 6$ in. (b) Acceleration polygon. (c) Free-body diagram and force polygon.

Example

EXAMPLE 14.3

For the mechanism illustrated in Fig. 14.8*a*, point A has a constant velocity $V_A = 12.6$ ft/s. The mechanism moves in a horizontal plane with gravity normal to the plane of motion. The weight and principal mass moment of inertia of coupler link 3 are 2.20 lb and $I_{G_3} = 0.047\,9$ in · lb · s^2, respectively. Determine the force $\mathbf{F}_A$ required for dynamic equilibrium of the mechanism. Assume that the weights of links 2 and 4 and friction in the mechanism are negligible.

SOLUTION

A kinematic analysis provides the acceleration information illustrated in the polygon of Fig. 14.8*b*. The acceleration of the mass center of the coupler link is $A_G = 444$ ft/s^2 and

the angular acceleration of this link is

$$\alpha_3 = \frac{A^t_{BA}}{R_{BA}} = \frac{(713\ \text{ft/s}^2)(12\ \text{in/ft})}{10\ \text{in}} = 856\ \text{rad/s}^2\ \text{cw}.$$

The mass of the coupler link is $m_3 = (2.20\,\text{lb})/(386\,\text{in/s}^2) = 0.005\,70\,\text{lb·s}^2/\text{in}$. Substituting this information into Eq. (14.17), the offset distance is

$$h = \frac{(0.047\,9\ \text{in} \cdot \text{lb} \cdot \text{s}^2)(856\ \text{rad/s}^2)}{(0.005\,70\ \text{lb} \cdot \text{s}^2/\text{in})(444\ \text{ft/s}^2)(12\ \text{in/ft})} = 1.35\ \text{in}$$

The free-body diagram of links 2, 3, and 4 and the resulting force polygon are illustrated in Fig. 14.8*c*. Note that the inertia force $-m\mathbf{A}_G$ is offset from G by the distance h so as to include a counterclockwise moment $-I_G\alpha_3$ about G and with the inertia force in the opposite sense to $\mathbf{A}_G$. The constraint reaction at B is $\mathbf{F}_{14}$ and, with no friction, is vertically downward. The forces at A are the constraint horizontal reaction $\mathbf{F}_{12}$ and the vertical actuating force $\mathbf{F}_A$. Recognizing this as a four-force member, as demonstrated in Section 13.8, we find the concurrency point at the intersection of the offset inertia force and $\mathbf{F}_{14}$, with the directions of both being known. The line of action of the total force $\mathbf{F}_{12} + \mathbf{F}_A$ at A must pass through this point of concurrency. This fact permits construction of the force polygon, where the unknown forces $\mathbf{F}_{12}$ and $\mathbf{F}_A$, having known directions, are found as components of $\mathbf{F}_{12}+\mathbf{F}_A$. The actuating force $\mathbf{F}_A$ is determined by measurement to be

$$\mathbf{F}_A = 27\hat{\mathbf{j}}\ \text{lb}. \qquad \textit{Ans.}$$