Mechanism Qualification Examination Examples

Reference 1: Chapter 1, Chapter 2, Chapter 4, Chapter 6, Chapter 7

Textbook: Mechanisms and Dynamics of Machinery, 4th Edition
Authors: Hamilton H. Mabie, Charles F. Reinholtz
ISBN: 978-0-471-80237-2, January, 1987, 656 Pages

1. Prob. 1.11 (P19)

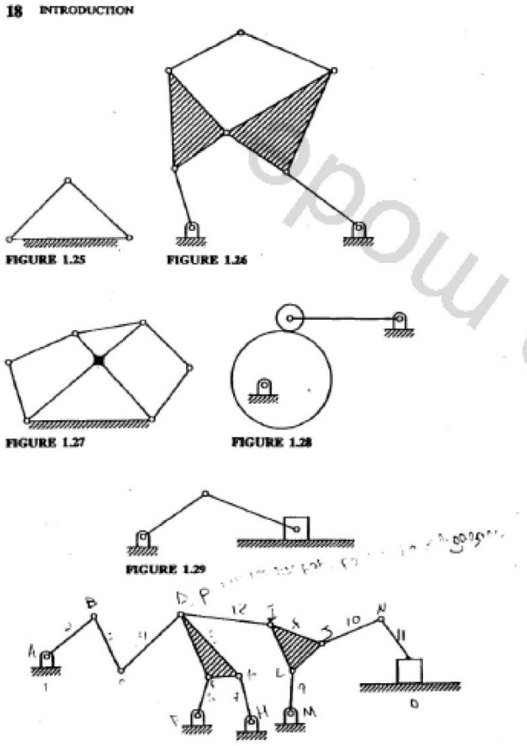


FIGURE 1.25 FIGURE 1.26 FIGURE 1.27 FIGURE 1.28 FIGURE 1.29

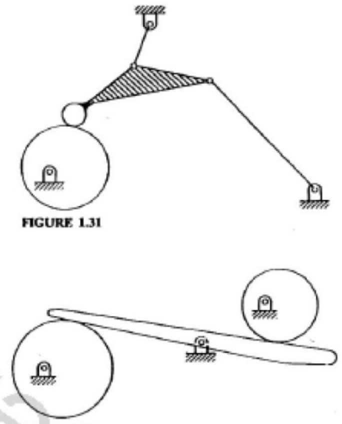


FIGURE 1.31

FIGURE 1.32

4 when link 2 is counterclockwise 45° from the horizontal. State whether or not ω_4 is constant.

1.10. A pulley of 100 mm diam drives one of 200 mm diam by means of a belt. If the angular velocity of the drive pulley is 65 rad/s and the center distance between pulleys is 400 mm, graphically determine the speed of the 200 mm pulley. Will its speed be constant?

1.11. Determine the mobility (number of degrees of freedom) of the devices shown in Figs. 1.25 through 1.32.

2. Prob. 2.5 (P63)
3. Prob. 2.8 (P63)

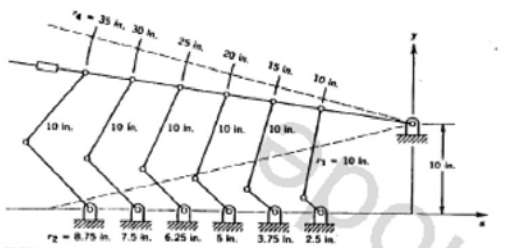
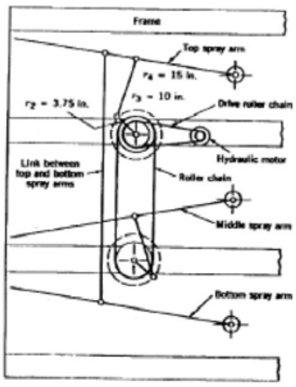


FIGURE 2.45



extreme position, the distance O_4B is to be 102 mm and at the other extreme position 229 mm. Determine the length of links 2 and 3, and draw the mechanism to scale as a check. Determine the maximum and the minimum transmission angles.

2.3. If for the drag-link mechanism shown in Fig. 2.5c, O_2A = 76.2 mm, AB = 102 mm, and O_4B = 127 mm, what can be the maximum length of O_2O_4 for proper operation of the linkage?

2.4. In the four-bar mechanism shown in Fig. 2.47, the guide is part of the fixed link and its centerline is a circular arc of radius R. Draw the mechanism full size and, using graphical construction, determine the magnitude of the angular velocity ω_4 of the slider when the mechanism is in the phase shown and ω_2 is 1 rad/s. Give the sense of ω_4.

2.5. Considering the slider-crank mechanism shown in Fig. 2.10b, derive equations for the displacement, velocity, and acceleration of the slider as a function of R, L, θ, ω, and ϕ. Do not make approximations. Let ω be constant.

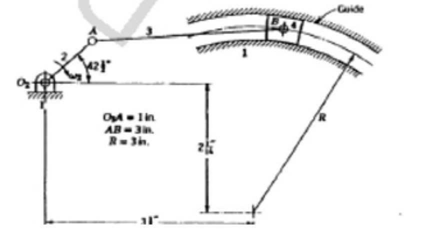
2.6. The approximate equation for the displacement of the slider in the slider-crank mechanism is $x = R(1 - \cos\theta) + (R^2/2L)\sin^2\theta$, and $\theta = \omega t$ because ω is constant. Derive the equations for the velocity and acceleration of the slider if ω is not constant.

2.7. Write a computer program to calculate the slider displacement, velocity, and acceleration of the slider crank shown in Fig. 2.10. Use both the exact equations and the approximate equations. Let $R = 2$ in., $L = 8$ in., $n_2 = 2400$ rpm. Calculate displacement, velocity, and acceleration at 10° intervals of θ from 0° to 360°.

2.8. A slider-crank mechanism has a crank length R of 50 mm and operates at 250 rad/s. Calculate the maximum values of velocity and acceleration and determine at what crank angles these maximums occur for connecting rod lengths of 200, 230, and 250 mm. Use approximate equations, and assume ω constant.

2.9. Write a computer program to compare simple harmonic motion of the Scotch yoke (Fig. 2.13) with the motion of the slider crank. Let n = 1800 rpm, R = 2 in., L = 8 in., for the slider crank and r = 2 in. for the Scotch yoke. Vary the angle θ from 0° to 360° (ccw) and calculate displacement, velocity, and acceleration at each value of θ. Use approximate equations for the slider crank, and assume ω constant.

2.10. In the mechanism shown in Fig. 2.48, neglect the connecting-rod effect (assume



4. Prob. 2.6

2.6. The approximate equation for the displacement of the slider in the slider-crank mechanism is $x = R(1 - \cos\theta) + (R^2/2L)\sin^2\theta$, and $\theta = \omega t$ because ω is constant. Derive the equations for the velocity and acceleration of the slider if ω is not constant.

5. Prob. 2.31

2.31. For the linkage of Fig. 2.56, construct a table showing the angles θ_3 and θ_4 as a function of θ_2 for 10° increments of θ_2 from 0° to 360°. Clearly indicate those values of θ_2 for which the mechanism will not assemble.

2.32. Find the range of angular positions for the input link (link 2) and for the output link (link 4) for the four-bar linkage shown in Fig. 2.57.

2.33. For the linkage shown in Fig. 2.58, find the angular positions of link 2 when link 4 is in the position shown. Be sure to consider both closures of the mechanism.

2.34. Determine the angular velocity of the crank of the slider-crank mechanism shown in Fig. 2.59.

2.35. For the linkage in Fig. 2.60, determine the values of θ_4 and γ when (*a*) $\theta_2 = -30°$; (*b*) $\theta_2 = 0°$; (*c*) $\theta_2 = 30°$.

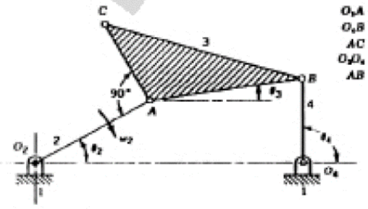


FIGURE 2.56

6. Prob. 4.3m

4.3m. The thickness of an involute gear tooth is 7.98 mm at a radius of 88.9 mm and a pressure angle of 14½°. Calculate the tooth thickness and radius at a point on the involute which has a pressure angle of 25°.

7. Prob. 4.13m

4.13m. A 3-module, 20° pinion of 18 teeth drives a 45-tooth gear. Calculate the pitch radii, base radii, addendum, dedendum, tooth thickness on the pitch circle, and the contact ratio.

8. Prob. 4.32m

4.32m. A 6-module, 20° pinion of 24 teeth drives a gear of 40 teeth. Calculate (*a*) the maximum theoretical distance that these gears can be drawn apart and still mesh together with continuous driving, and (*b*) the backlash on the new pitch circles when the gears are drawn apart the amount calculated in part *a*.

9. Prob. 6.4m

6.4m. A pair of Gleason miter gears have 20 teeth and a module of 6.35. Calculate the pitch diameter, the addendum and dedendum, the face width, the pitch cone distance, the face angle, the root angle, and the outside diameter. Make a full-size axial sketch of the gears in mesh using reasonable proportions for the hub and web as shown in Fig. 6.7*a*. Dimension the drawing with the values calculated.

10. Prob. 6.40m

6.40m. A double-threaded worm drives a 31-tooth worm gear with shafts at 90°. If the center distance is 210.0 mm and the lead angle of the worm 18.83°, calculate the axial pitch of the worm and the pitch diameters of the two gears.

11. Prob. 7.20

12. Prob. 7.21

7.20. In the planetary gear train shown in Fig. 7.36, determine the angular-velocity ratio ω_7/ω_2. Compare this ratio with that obtained if the arm 4 is connected directly to the output shaft and gears 5, 6, and 7 are omitted.

7.21. In the gear train for Problem 7.20, gear 2 rotates at 600 rpm in the direction shown and gear 1 (and gear 6) rotates at 300 rpm in the opposite direction. Calculate the speed and direction of rotation of gear 7.

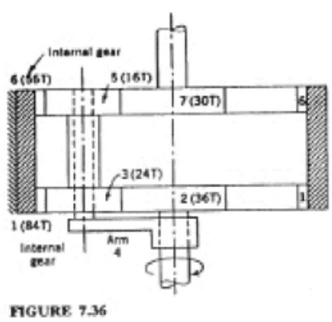


FIGURE 7.36

Reference 2: Chapter 3, Chapter 9, Chapter 12, Chapter 13

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13. Prob. 3-2

3-2 In Fig. P3-2 crank 2 is to rotate continuously and 4 is to oscillate. What are the maximum and minimum values in millimeters which can be used for the coupler length?

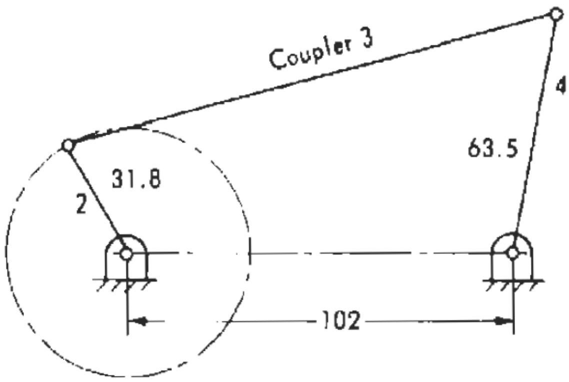


Figure P3-2

14. Prob. 9-1

9-1 Using the results of Sec. 9-2, compute the velocity in feet per second and acceleration in feet per second squared of the slider in Fig. P9-1 for $\theta = 0°, 45°, 90°, 135°$, and $180°$.

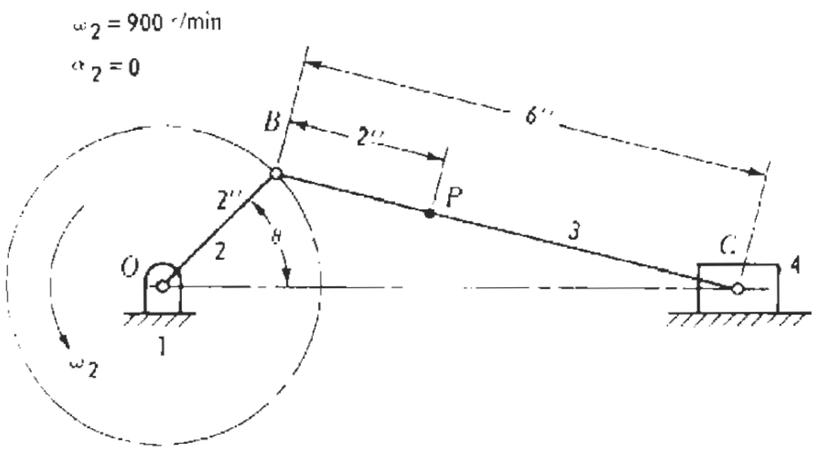


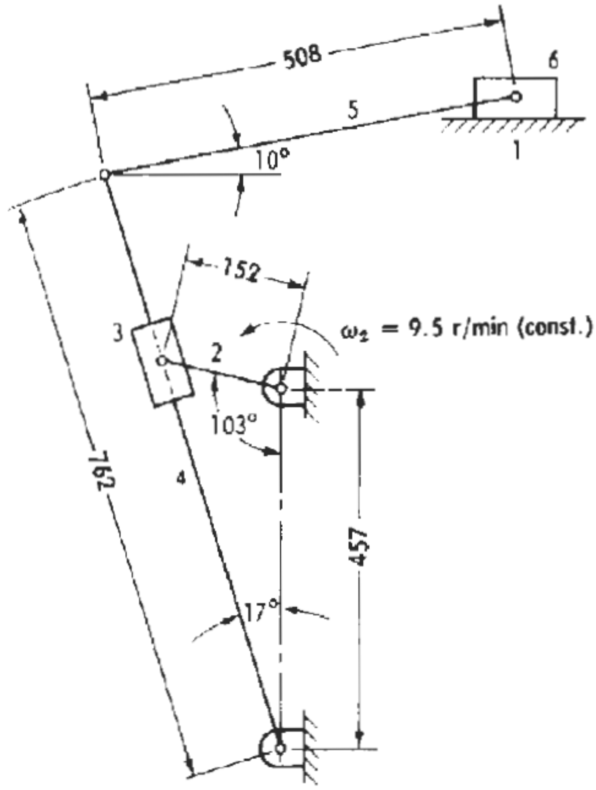
Figure P9-1

15. Prob. 9-7

16. Prob. 9-8

9-7 Use the equations of Sec. 9-4 to find the velocity in meters per second and acceleration in meters per second squared of slider 6 of the shaper mechanism in Fig. P9-7.

9-8 For the cam mechanism in Fig. P7-16 draw an equivalent linkage of the crank-shaper type and compute the values of ω_4 in radians per second and α_4 in radians per second squared using the equations of Sec. 9-4.



17. Prob. 12-1

12-1 A pair of meshing spur gears has 22 and 38 teeth, a diametral pitch of 8, and a pinion running at 1,800 r/min. Determine the following: (*a*) pitch diameters, (*b*) center distance, (*c*) circular pitch, (*d*) pitch-line velocity in feet per minute, and (*e*) revolutions per minute of the gear.

18. Prob. 12-6

12-6 A pair of spur gears has 16 and 18 teeth, a module of 13 mm, addendum of 13 mm, and pressure angle of $14\frac{1}{2}°$. Show that the gears have interference. Determine graphically the amount by which the addendums must be reduced if the interference is to be eliminated. Measure the length of the path of contact for this new condition and compute the contact ratio.

19. Prob. 13-1

13-1 Determine the revolutions per minute and direction of rotation of gear G in the gear train shown in Fig. P13-1.

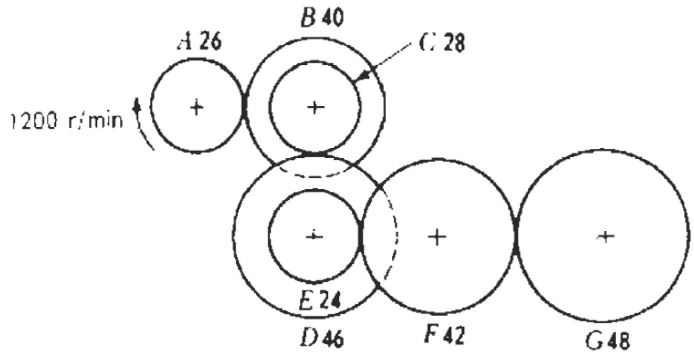


Figure P13-1

20. Prob. 13-7

13-7 Determine the speed of rotation of the output shaft in Fig. P13-7 and its direction of rotation when viewed from the right end.

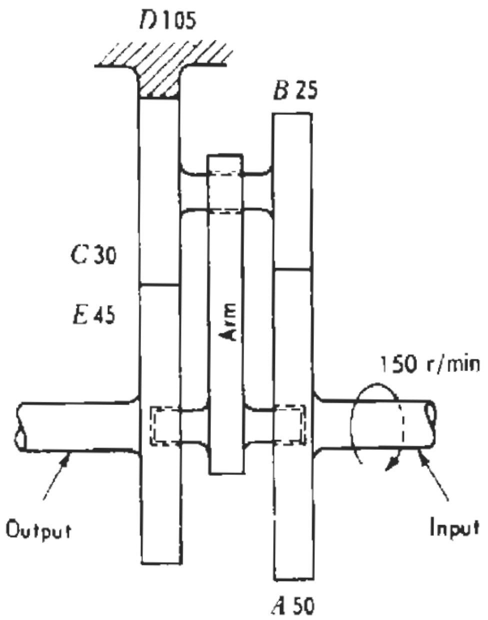


Figure P13-7