

EMTR-2019
Assignment #2 Reference Solutions

Q6: Problem 7.12

Reference Solution:

$$Q_{\max} = 0.002 \text{ m}^3 / \text{s}, \rho = 1000 \text{ kg} / \text{m}^3$$

$$Q = A_v \sqrt{\frac{\Delta P}{\rho}}$$

$$A_v = \frac{Q}{\sqrt{\frac{\Delta P}{\rho}}} = 0.002 / \sqrt{\frac{100 \times 10^3}{1000}} = 20 \times 10^{-5}$$

You can also use $Q = 2.37 \times 10^{-5} C_v \sqrt{\frac{\Delta P}{\rho}}$ for calculation.

From the related Table, the valve size is 480 mm in theory. In practice, we should use other tables for dimension estimation, as illustrated in lectures.

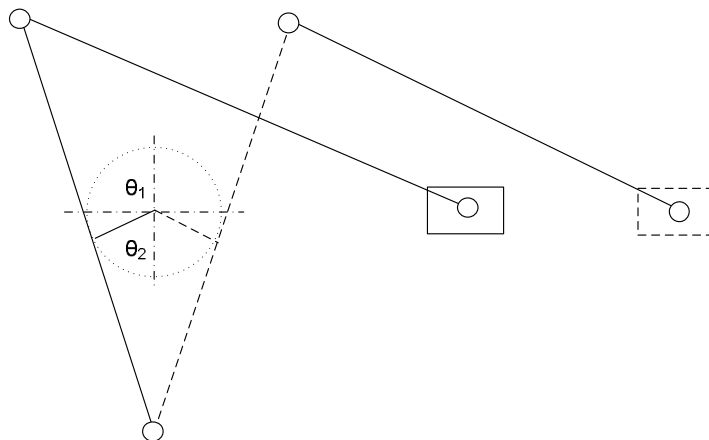
Problem 8.3

Reference solution:

- (a) A car hood hinge mechanism: DOF = 1
- (b) An estate car tailgate mechanism: DOF = 2 (one up and one down).
- (c) A windscreen wiper mechanism: DOF = 1
- (d) Your knee: DOF = 1 (one rotation)
- (e) Your angle: DOF = 3 (three rotations)

Problem 8.5

Reference solution:



$\theta_1 > \theta_2$, so it is a quick return system.

Problem 8.6

Reference solution:

Draw the displacement diagram from the cam center to the follower contact point, with respect to different cam rotation angles of $0\sim 360^\circ$. It has a sudden drop in displacement followed by a gradual rise back up again.

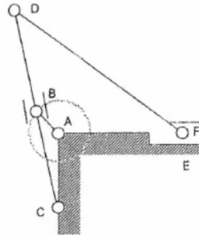
Problem 8.9

Reference solutions:

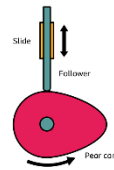
(a) For example, a cam on a shaft mechanism:



(b) For example, a quick-retune mechanism:



(c) For example, an eccentric cam mechanism:



(d) For example, a rack-and-pinion mechanism:



(e) For example, a timing belt drive:



(f) For example, a bevel gear system:



Problem 8.10

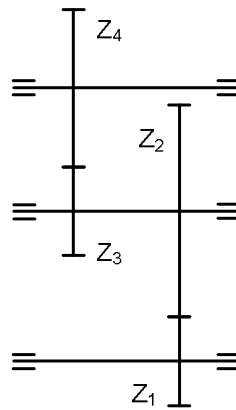
Reference solution:

$$Z_1 = 15 \text{ (too small)}$$

$$Z_2 = 90$$

$$Z_3 = 15 \text{ (too small)}$$

$$Z_4 = 60$$



The overall GR =

$$\frac{\omega_4}{\omega_1} = \frac{n_4}{n_1} = \frac{Z_3}{Z_4} \times \frac{Z_1}{Z_2} = \frac{15}{60} \times \frac{15}{90} = \frac{1}{24}$$

$$n_4 = 1200 \text{ rpm}; \omega_4 = \frac{2\pi \times 1200}{60} = 40\pi \text{ (rad/sec)}; T_4 = P / \omega_4 = 2000 / (40\pi) = 15.916 \text{ Nm.}$$

$$n_3 = n_4 \frac{60}{15} = 4800 \text{ rpm}; \omega_3 = \frac{2\pi \times 4800}{60} = 160\pi \text{ (rad/sec)}; T_3 = 2000 / (160\pi) = 3.979 \text{ Nm.}$$

$$n_2 = n_3 = 4800 \text{ rpm}; \omega_2 = \frac{2\pi \times 4800}{60} = 160\pi \text{ (rad/sec)}; T_2 = 2000 / (160\pi) = 3.979 \text{ Nm.}$$

$$n_1 = n_2 \frac{90}{15} = 28800 \text{ rpm}; \omega_1 = \frac{2\pi \times 28800}{60} = 960\pi \text{ (rad/sec)}; T_1 = 2000 / (960\pi) = 0.663 \text{ Nm.}$$