1. Disk 2 with center $O$ rotates with angular velocity $\omega_2$ as shown in Figure. What is the angular velocity of link 3?

$$\omega_3 = \phantom{0} \text{rad/s}$$

2. Disk 2 roles on the ground with no slip. The velocity of its center $A$ is shown in the Figure. Draw on the Figure below the velocity of $B$ with the correct amplitude and direction.

$$v_A = 1 \text{ in./s}$$
3. Slider $A$ moves with velocity $\mathbf{v}_A$ as shown in the figure. What is the angular velocity $\omega_2$ of link 2?

$$\omega_2 = \text{rad/s}$$

4. The figure shows a rigid body with three points $A$, $B$, $C$, attached to it. The velocity of $A$ and $B$ are $\mathbf{v}_A$ and $\mathbf{v}_B$, respectively. Draw on the figure the velocity $\mathbf{v}_C$ of $C$ in its correct magnitude and direction.
5. Link 2 rotates with angular velocity \( \omega_2 \). For the instant shown in the figure, what is the angular velocity \( \omega_4 \) of link 4?

\[
\omega_4 = \text{rad/s}
\]

6. For the instant shown in the figure, link 3 is parallel to the line of centers \( \overline{O_2O_4} \). If the angular velocity of link 2 is \( \omega_2 \), what is the angular velocity \( \omega_4 \) of link 4?

\[
\omega_4 = \text{rad/s}
\]

7. For the instant shown in the figure the angular velocity of link 2 is \( \omega_2 \). What is the angular velocity \( \omega_4 \) of link 4?

\[
\omega_4 = \text{rad/s}
\]
8. The transmission angle $\theta_r$ of the four bar linkage is shown in Figure (a) below. Draw in Figure (b) the configuration of the mechanism where $\theta_r$ is minimal.

9. The angle $\phi$ that link 4 forms with a horizontal line through $O_4$ is shown in Figure (a) below. Draw in Figure (b) the configuration of the mechanism which maximizes $\phi$.

10. Link 2 rotates with $\omega_2$ as shown in Figure (a) below. Draw in Figure (b) the configuration for which the mechanism is locked.
11. For the instant shown in the figure, link 3 is parallel to the line of centers $O_2O_4$. If the angular velocity of link 2 is $\omega_2$, what is the angular velocity $\omega_6$ of link 6?

\[ \omega_6 = \quad \text{rad/s} \]

12. Determine the mobility of the system shown in the figure below

M=

13. Determine the mobility of the system shown in the figure below

M=
14. Determine the mobility of the system shown below

\[ M = \]

15. Point \( P \) in the pantograph shown below moves along the line \( A-B \). At the same time point \( Q \) moves along a line \( C-D \). If the distance form \( A \) to \( B \) is 2 in., what is the distance from \( C \) to \( D \)?

**Dimensions:** Links 2, 3, and 4 are 1.5 in. long.
Link 5 is 4 in. long

\[ CD = \text{in.} \]
16. Approximate the time ratio in the quick return mechanism shown below

\[ TR = \]

17. Slider 4 slides on the semi-circle which is attached to the ground. Link 2 rotates with angular velocity \( \omega_2 \). What is the angular velocity \( \omega_4 \) of slider 4?

\[ \omega_4 = \text{rad/s} \]
18. A vector loop equation is defined for the mechanism shown below, where $O$ is a fixed point. Let $f_1(r_2, r_3)$ be the $x$-component of the vector loop equation.

Determine the element $J_{12}$ associated with the equation

\[
\begin{bmatrix}
J_{11} & J_{12} \\
J_{21} & J_{22}
\end{bmatrix}
\begin{bmatrix}
\Delta r_2 \\
\Delta r_3
\end{bmatrix}
= \begin{bmatrix}
f_1 \\
f_2
\end{bmatrix}
\]

$J_{12} =$

19. The four bars shown in the figure below are titled $a$, $b$, $c$ and $d$. If the mechanism is a crank-crank mechanism, which of the four links is the ground?

$\text{Link }$ $a$ $b$ $c$ $d$

20. The figure shows a rigid body with two points $A$ and $B$ attached to it. The velocity of $A$ and $B$ are $v_A$ and $v_B$, respectively. Draw the point $C$ on the rigid body which has zero velocity.
Bonus Question

21. The velocity \( v_p \) of point \( P \) in the pantograph is shown in the figure below. What is the angular velocity \( \omega_4 \) of link 4?

**Dimensions:** Links 2, 3, and 4 are 1.5 in. long.
Link 5 is 4 in. long

\[ \omega_4 = \text{rad/s} \]