22. **Picture the Problem:** For an object moving along the x axis, the potential energy of the frictionless system is shown in the figure. The object is released from rest at point A.

**Strategy:** The principle of conservation of energy states that the sum of the potential and kinetic energies of an object remains constant if there are no nonconservative forces. Therefore, any decrease in potential energy is accompanied by an increase in the kinetic energy of the same magnitude. Use this principle to evaluate the speed of the object at the various other points in the figure.

**Solution:** Point G is at the same potential energy as point A, so the kinetic energy and the speed of the object will be zero at point G. For the other points, the lower the potential energy, the higher the kinetic energy and the speed. Using this reasoning we arrive at the ranking of speeds: \[ A = G < B = D = F < E < C. \]

**Insight:** The object could not move to the right of point G unless it were given some additional mechanical energy.

23. **Picture the Problem:** For an object moving along the x axis, the potential energy of the frictionless system is shown in the figure. The object is released from rest at a point halfway between the points F and G.

**Strategy:** The principle of conservation of energy states that the sum of the potential and kinetic energies of an object remains constant if there are no nonconservative forces. Therefore, any decrease in potential energy is accompanied by an increase in the kinetic energy of the same magnitude. Use this principle to evaluate the speed of the object at the various other points in the figure.

**Solution:** The object is released from a point below points A and G, so it will not be able to reach those locations. For the other points, the lower the potential energy, the higher the kinetic energy and the speed. Using this reasoning we arrive at the ranking of speeds: \[ B = D = F < E < C. \]

**Insight:** The object could only reach points A and G if it were given some additional mechanical energy.

24. **Picture the Problem:** A swimmer descends through a vertical height of 2.31 m as she slides without friction.

**Strategy:** As the swimmer descends the slide her gravitational potential energy is converted into kinetic energy. Set the loss in gravitational potential energy equal to the gain in kinetic energy by setting her change in mechanical energy equal to zero, so that \( \Delta E = E_i - E_f = 0 \) or \( E_i = E_f \). Let \( v = 0 \) at the bottom of the slide, \( v = 0 \) at the top.

**Solution:** Set \( E_{bottom} = E_{top} \) and solve for \( v_{bottom} \):

\[
\begin{align*}
E_{bottom} &= E_{top} \\
K_{bottom} + U_{bottom} &= K_{top} + U_{top} \\
\frac{1}{2}mv_{bottom}^2 + 0 &= 0 + mgv_{top} \\
v_{bottom} &= \sqrt{2gy_{bottom}} = \sqrt{2\left(9.81 \text{ m/s}^2\right)(2.31 \text{ m})} = 6.73 \text{ m/s}
\end{align*}
\]

**Insight:** If she has a mass of 40 kg, the swimmer loses 906 J of potential energy and gains 906 J of kinetic energy.
25. **Picture the Problem:** A swimmer descends through a vertical height of 2.31 m as she slides without friction.

**Strategy:** As the swimmer descends the slide her gravitational potential energy is converted into kinetic energy. Set the loss in gravitational potential energy equal to the gain in kinetic energy by setting her change in mechanical energy equal to zero, so that $\Delta E = E_f - E_i = 0$ or $E_f = E_i$. Let $y = 0$ at the bottom of the slide, $v = 0.840 \text{ m/s}$ at the top.

**Solution:** Set $E_{\text{bottom}} = E_{\text{top}}$ and solve for $v_{\text{bottom}}$:

$$
E_{\text{bottom}} = E_{\text{top}} \\
K_{\text{bottom}} + U_{\text{bottom}} = K_{\text{top}} + U_{\text{top}} \\
\frac{1}{2}mv_{\text{bottom}}^2 + 0 = \frac{1}{2}mv_{\text{top}}^2 + mgy_{\text{top}} \\
v_{\text{bottom}} = \sqrt{\frac{v_{\text{top}}^2 + 2gy_{\text{top}}}{1}} \\
v_{\text{bottom}} = \sqrt{\left(0.840 \text{ m/s}\right)^2 + 2\left(9.81 \text{ m/s}^2\right)(2.31 \text{ m})} \\
v_{\text{bottom}} = 6.78 \text{ m/s}
$$

**Insight:** Note that she is not going 0.840 m/s faster than the 6.73 m/s she would be traveling if she started from rest (see the previous problem). That’s because the 14.1 J of kinetic energy she has at the start (if she has a mass of 40 kg) is small compared with the 906 J of kinetic energy she gains on the way down.

26. **Picture the Problem:** As the ball flies through the air and gains altitude some of its initial kinetic energy is converted into gravitational potential energy.

**Strategy:** Set the mechanical energy at the start of the throw equal to the mechanical energy at its highest point. Let the height be $y_i = 0$ at the start of the throw, and find $y_f$ at the highest point.

**Solution: 1. (a)** Set $E_i = E_f$ and solve for $y_f$:

$$
E_i = E_f \\
K_i + U_i = K_f + U_f \\
\frac{1}{2}mv_i^2 + 0 = \frac{1}{2}mv_f^2 + mgy_f \\
y_f = \frac{1}{2g}(v_i^2 - v_f^2) = \frac{(8.30 \text{ m/s})^2 - (7.10 \text{ m/s})^2}{2(9.81 \text{ m/s}^2)} = 0.942 \text{ m}
$$

2. (b) The height change is independent of the mass, so doubling the ball’s mass would cause no change to (a).

**Insight:** A more massive ball would have more kinetic energy at the start, but would require more energy to change its height by 0.942 m, so the mass cancels out.