Quiz 3: A 0.5-lb particle freely swirls around the inside surface of a smooth, funnel-shaped glass vessel tethered to a light string which is drawn down through the narrow funnel stem and attached to the ground. Initially, the particle is observed to be moving steadily along a horizontal circular path with the string fully extended at a distance of 2 ft from the 'point' of the funnel as depicted in the diagram at left.

(a) Determine the tension \( T_1 \) in the string given that it completes one full revolution every second. [Simple ME 215 type calculation]

(b) Calculate the particle speed \( v_2 \) after someone grabs the stem of the 2.5-lb funnel and slowly raises it to a new stationary position 1 ft above the original.

(c) Neglecting frictional effects, determine the work done by the modifying agent. (Carefully consider the change in gravitational potential energy.)

\[ \omega_1 = \frac{2\pi \text{ rad}}{1 \text{ sec}} \quad \text{rel} \quad \Rightarrow \quad r_1 \omega_1^2 = \sqrt{3} \text{(2\pi)}^2 = 4\sqrt{3} \pi^2 \quad ; \quad (SCM) \]

\[ \sum \vec{F} = m\vec{a} \quad \Rightarrow \quad T_1 + mg \sin 30 = m \left( 4\sqrt{3} \pi^2 \right) \left( \frac{v_2}{2} \right) = m6\pi^2 \]

\[ T_1 = m \left( 6\pi^2 - \frac{1}{2}g \right) = \frac{6\pi^2 - 16.1}{64.4} \]

\[ T_1 = 0.6695 \text{ lbs} \]

\[ \frac{\text{Cons of A't Mo}}{\text{Not Energy!!}} : \quad \left( \frac{r_1 v_1}{r_2 v_2} \right) = \left( \frac{\sqrt{3} \pi}{2} \right)^2 \Rightarrow \quad v_2 = 2.51 \approx 4\sqrt{3} \pi \approx 21.766 \text{ ft/sec} \]

\[ \text{vertical disp. of 1/2-lb block} \]

\[ \text{Work} = \Delta E = \frac{1}{2} m (v_2^2 - v_1^2) + (2.5)(1) + \left( \frac{1}{2} \right)(2) \]

\[ = \frac{14}{2} \left( \frac{v_2}{2} \right) (16 - 4) 3\pi^2 + 2.5 + 1.25 = \frac{36\pi^2}{4(32.2)} + 2.75 \]

\[ \text{Work} = 2.759 + 2.75 \]

\[ \text{Work} \approx 5.506 \text{ ft-lb} \]
Quiz #4: For the instant represented, the slotted triangular plate is rotating in the CCW direction with a constant angular speed of 4 rad/sec. about its fixed pin support at B. The pin C welded to link AD is fitted into the plate-slot so that the above described plate motion 'transfers' rotational motion to the link about its fixed pin support at A.

(a) Determine the instantaneous angular velocity vector (magnitude & rotational direction) of the link AD.

(b) At this same instant, determine the angular acceleration (vector) of the link AD.

Hint: The pin C has a particularly simple type of motion relative to the ground.

\[ \vec{V}_{c/B} = \vec{V}_c - \vec{V}_B = \vec{V}_c + \omega_x \times \vec{r}_{c/B} \]

\[ \vec{V}_c = 7 \omega_1 \hat{j}; \text{ SCM} \]

\[ \vec{V}_{c/2} = \vec{V}_{rel} - \left( \frac{4}{3} \hat{i} - \frac{3}{2} \hat{j} \right) \]

\[ \omega_x = 4 \hat{k}; \omega_x = 4 \]

\[ \vec{F}_C = 4 \hat{i} - 3 \hat{j} \]

\[ \omega_1 = 7 \]

\[ \vec{U}_{rel} = 15 \text{ in/sec} \]

\& \quad \omega_1 = 16 - \frac{3}{5}(15) = 16 - 9 = 7 \Rightarrow \omega_1 = 1.0 \text{ rad/sec CCW} \]

(b) \[ \vec{A}_c - \vec{A}_B = \vec{A}_{c/2} + \omega_x \times \vec{r}_{c/B} + 2 \omega_x \times \vec{V}_{c/2} - \omega_x^2 \vec{r}_{c/B} \]

\[ \vec{A}_c = 7 \omega_1 \hat{j} - 7(4 \hat{i}) \]

\[ \vec{V}_{c/2} = \vec{V}_{rel} - \left( \frac{4}{3} \hat{i} - \frac{3}{2} \hat{j} \right); \vec{U}_{rel} = ? \]

\[ -7 \hat{i} + 7 \omega_1 \hat{j} = - \frac{4}{3} \vec{U}_{rel} \hat{i} - \frac{3}{2} \vec{U}_{rel} \hat{j} + 8 \hat{k} \times (-12 \hat{i} - 9 \hat{j}) - 16 \left( \frac{4}{3} \hat{i} - \frac{3}{2} \hat{j} \right) \]

\[ -96 \hat{j} + 72 \hat{i} - 64 \hat{i} + 48 \hat{j} \]

\[ \begin{align*}
\vec{U}_{rel} & = 15 \Rightarrow \vec{U}_{rel} = 18.75 \text{ in/sec} \to A \\
\end{align*} \]

\[ \text{Bar AD rotating@ 1.0 rad/sec. in CCW direction but slowing down@ 8.464 \times 10^{-3} \text{ rad/sec}^2} \]

\[ \begin{align*}
\vec{A}_i = \vec{\omega}_i & = -(6A + 48) \quad \text{to} \quad -8.464 \text{ rad/sec}^2 \\
\end{align*} \]