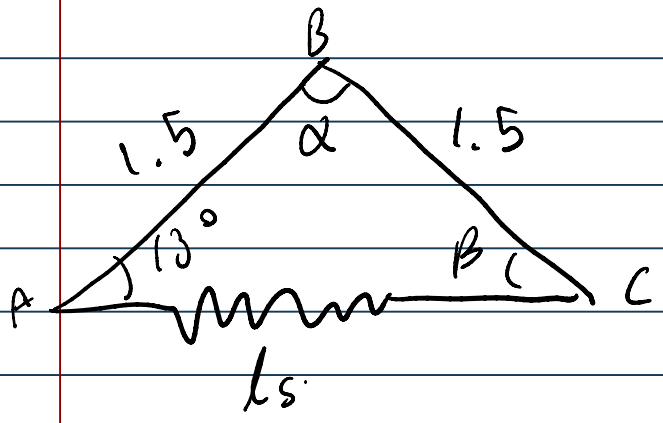
Q4

December 15, 2021 12:25 AM



$$\frac{\sin(13)}{1.5} = \frac{\sin(\beta)}{1.5}$$

$$\beta = 13°$$

$$\angle\alpha = 180 - \beta - \theta$$

$$\angle\alpha = 154°$$

$$\frac{\sin(154°)}{l_s} = \frac{\sin(14°)}{1.5}$$

$$l_s = \frac{1.5\sin(154°)}{\sin(14°)}$$

$$l_s = 2.72\ m$$

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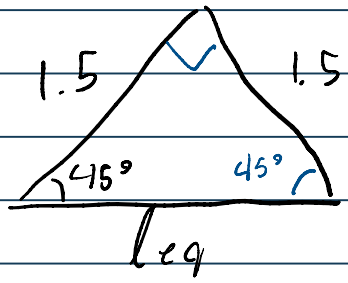
b) $V_e = \frac{1}{2} k s^2$



$s = l_s - l_{equilibrium}$

$s = 2.72 - \sqrt{1.5^2 + 1.5^2}$

$s = 0.599\ m$

$V_e = \frac{1}{2}\left(5 \frac{N}{m}\right)(0.599)^2$

$V_e = 0.897\ J$

Q5

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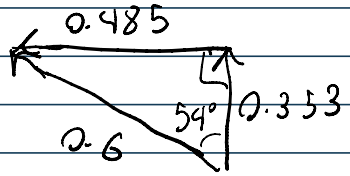
$\ell_D = 1.1\,m \quad a_C = 8.0\,m/s^2 \uparrow$

$\ell_B = 0.6\,m \quad \theta = 54°$

$V_C = 4.5\,m/s \downarrow \quad \phi = 27°$

a)

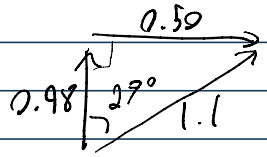


general plane motion

$V_B = \omega_{AB} \times r_{AB}$

$V_B = \omega_{AB}\hat{k} \times (-0.485\hat{i} + 0.353\hat{j})$

(1) $V_B = -0.485\,\omega_{AB}\hat{j} - 0.353\,\omega_{AB}\hat{i}$



$V_{B/C} = \omega_{BC} \times r_{BC}$

$V_{B/C} = \omega_{BC}\hat{k} \times (0.5\hat{i} + 0.98\hat{j})$

$V_{B/C} = 0.50\,\omega_{BC}\hat{j} - 0.98\,\omega_{BC}\hat{i}$

$V_B = V_C + V_{B/C}$

(2) $V_B = -4.5\hat{j} + 0.50\,\omega_{BC}\hat{j} - 0.98\,\omega_{BC}\hat{i}$

solve (1) & (2) by components

(3) $y: -4.5 + 0.50\omega_{BC} = -0.485\omega_{AB}$

$x: -0.98\omega_{BC} = -0.853\omega_{AB}$

(4) $\omega_{BC} = 0.360\omega_{AB}$

sub (4) into (3) & solve

$-4.5 + 0.50(0.36\omega_{AB}) = -0.485\omega_{AB}$

$-4.5 = -0.665\omega_{AB}$

$\underline{\omega_{AB} = (6.77\hat{k})\ rad/s}$

sub ω_{AB} into (4)

$\omega_{BC} = 0.364(6.77)$

$\underline{\omega_{BC} = (2.46\hat{k})\ rad/s}$

b) $a_B = a_C + \alpha_{BC} \times r_{BC} - \omega_{BC}^2 \cdot r_{BC}$

$a_B = \alpha_{AB} \times r_{B/A} - \omega_{AB}^2 r_{B/A}$

$a_B = \alpha_{AB} \times (-0.485\hat{i} + 0.353\hat{j}) - (6.77)^2 (-0.485\hat{i} + 0.353\hat{j})$

(1) $a_B = -0.485\hat{j}\,\alpha_{AB} - 0.353\hat{i}\,\alpha_{AB} - 22.2\hat{i} + 16.18\hat{j}$

$a_B = 8.0\hat{j} + \alpha_{BC}(0.5\hat{i} + 0.98\hat{j}) + (2.46)^2(0.5\hat{i} + 0.98\hat{j})$

$$a_B = 8.0\hat{j} + \alpha_{BC}(0.5\hat{i} + 0.98\hat{j}) + (2.46)^2(0.5\hat{i} + 0.98\hat{j})$$

(2) $$a_B = 8.0\hat{j} + 0.5\hat{j}\alpha_{BC} - 0.98\hat{i}\alpha_{BC} + 3.03\hat{i} + 5.93\hat{j}$$

$$x: -0.353\alpha_{AB} - 22.2 = -0.98\alpha_{BC} + 3.03$$

$$\alpha_{AB} = \frac{25.23 - 0.98\alpha_{BC}}{-0.353}$$

(3) $$\alpha_{AB} = -71.47 + 2.78\alpha_{BC}$$

$$j: 8.0 + 0.5\alpha_{BC} + 5.93 = -0.485\alpha_{AB} + 16.18$$

$$0.5\alpha_{BC} = 2.25 - 0.485(-71.47 + 2.78\alpha_{BC})$$

$$0.5\alpha_{BC} = 2.25 + 34.66 - 1.35\alpha_{BC}$$

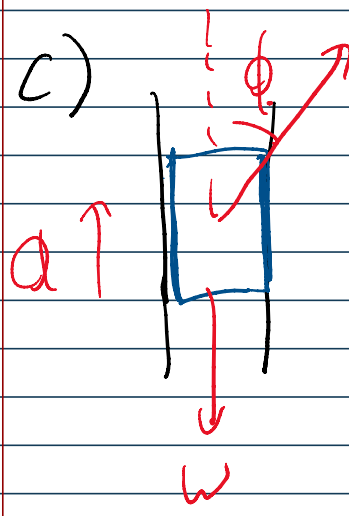
$$1.85\alpha_{BC} = 36.91$$

$$\alpha_{BC} = 19.95 \text{ rad/s}^2$$

$$\alpha_{AB} = -71.7 + 2.78(19.95)$$

$$\alpha_{AB} = -16.23 \text{ rad/s}^2$$

c)



$\Sigma F = ma$

$+\uparrow \Sigma F_y = (9kg)(8 m/s)$

$\Sigma F_y = 72\ N$

$72 = -w + F_{BC}\cos\phi$

$72 = (-9.81)(9) + F_{BC}\cos\phi$

$160.29 = F_{BC}\cos(27°)$

$|F_{BC}| = 180.0\ N$

$F_{BC} = 180.0N\ [63° up\ from\ +x]$

$\vec{F}_{BC} = \langle 180\sin(27)\hat{i} + 180\cos(27)\hat{j} \rangle$

$\vec{F}_{BC} = \langle 81.72\hat{i} + 160.4\hat{j} \rangle$

Q6

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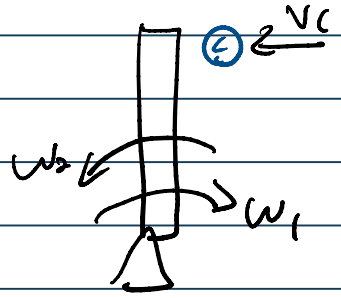

$L = 2.5\,m$

$m = 15\,kg$

$(V_C)_1 = 4.6\,m/s \leftarrow$

$\omega_1 = 1.4\,rad/s$ ↻

a) elastic, no energy lost

$e = 1$

$$e = \frac{(V_C)_2 - (V_{AB})_2}{(V_{AB})_1 - (V_C)_1} = 1$$

$(V_{AB})_1 = \omega_1 L$

$(V_C)_2 - (V_{AB})_2 = (2.5)(1.4) + 4.6\,m/s$

(1) $(V_C)_2 - (V_{AB})_2 = 8.1 \rightarrow (V_C)_2 = 8.1 + (V_{AB})_2$

$m_{AB}(V_{AB})_1 + m_C(V_C)_1 = m_{AB}(V_{AB})_2 + m_C(V_C)_2$

$(15)(2.5 \cdot 1.4) + (30)(4.6) = (15)(V_{AB})_2 + 30(V_C)_2$

$190.5 = 15(V_{AB})_2 + 30(8.1 + (V_{AB})_2)$

$190.5 = 15(V_{AB})_2 + 243 + 30(V_{AB})_2$

$$-52.5 = 45(V_{AB})_2$$

$$(V_{AB})_2 = -1.167 \text{ m/s}$$

$$(\omega_{AB})_2 = \frac{V}{r} = \frac{-1.167}{2.5} = -0.4668$$

$$\underline{(\omega_{AB})_2 = 0.467 \text{ rad/s CCW}}$$

$$(V_C)_2 = 8.1 + (V_{AB})_2$$

$$\underline{(V_C)_2 = 6.93 \text{ m/s} \rightarrow}$$

energy Eqt

$$E = \left[\frac{1}{2} m_{AB} (V_{AB})_1^2 + \frac{1}{2} m_C (V_C)_1^2\right]$$

$$- \left[\frac{1}{2} m_{AB} (V_{AB})_2^2 + \frac{1}{2} m_C (V_C)_2^2\right]$$

$$\Delta E = \frac{1}{2}(15)(1.167)^2 + \frac{1}{2}(10)(1.1)^2$$

$$\Delta E = \frac{1}{2}(15)(1.4 \cdot 2.5)^2 + \frac{1}{2}(30)(4.6)^2$$

$$-\left(\frac{1}{2}(15)(0.467 \cdot 2.5)^2 + \frac{1}{2}(30)(6.93)^2\right)$$

$$\Delta E = -321.3$$

$$E_{lost} = 321.3 \text{ J}$$