Solutions

2.1

- $\omega = 2\pi N/60 = 2\pi \times 600/60 = \mathbf{62.83}$ rad/s.
- $v_B = r\omega = 0.05 \times 62.83 = \mathbf{3.142}$ m/s.

2.2

- $v_C = r\omega \sin(\theta+\phi)/\cos\phi = 3.142 \sin 55.18°/\cos 10.18° = \mathbf{2.620}$ m/s.
- $\omega_3 = r\omega\cos\theta/(l\cos\phi) = 3.142\cos 45°/(0.2\cos 10.18°) = \mathbf{11.28}$ rad/s.
- $v_{CB} = \omega_3 l = 11.28 \times 0.2 = \mathbf{2.257}$ m/s, across the rod.

2.3

- $a_{Cor} = 2\omega v_{rel} = 2 \times 8 \times 0.4 = \mathbf{6.4}$ m/s^2.
- Perpendicular to the arm, towards the side the arm is turning (the sliding velocity rotated 90° with ω).

3.1

- (a) $a_B = r\omega^2 = 0.05 \times 62.83^2 = \mathbf{197.4}$ m/s^2, towards O.
- Rod centripetal $\omega_3^2 l = 11.28^2 \times 0.2 = \mathbf{25.5}$ m/s^2, from C towards B.
- (b) $n = l/r = 4$; $a_C \approx r\omega^2(\cos\theta + \cos 2\theta/n) = 197.4(0.7071 + 0) = \mathbf{139.6}$ m/s^2.
- Directed towards the crank: past outer dead centre the piston is speeding up as it moves in.
- (c) $F = ma_C = 1.2 \times 139.6 = \mathbf{168}$ N.
- The dropped terms are of order $(r/l)^3$; with $n = 4$ the exact polygon gives 140.4 m/s^2, 0.6% more.

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