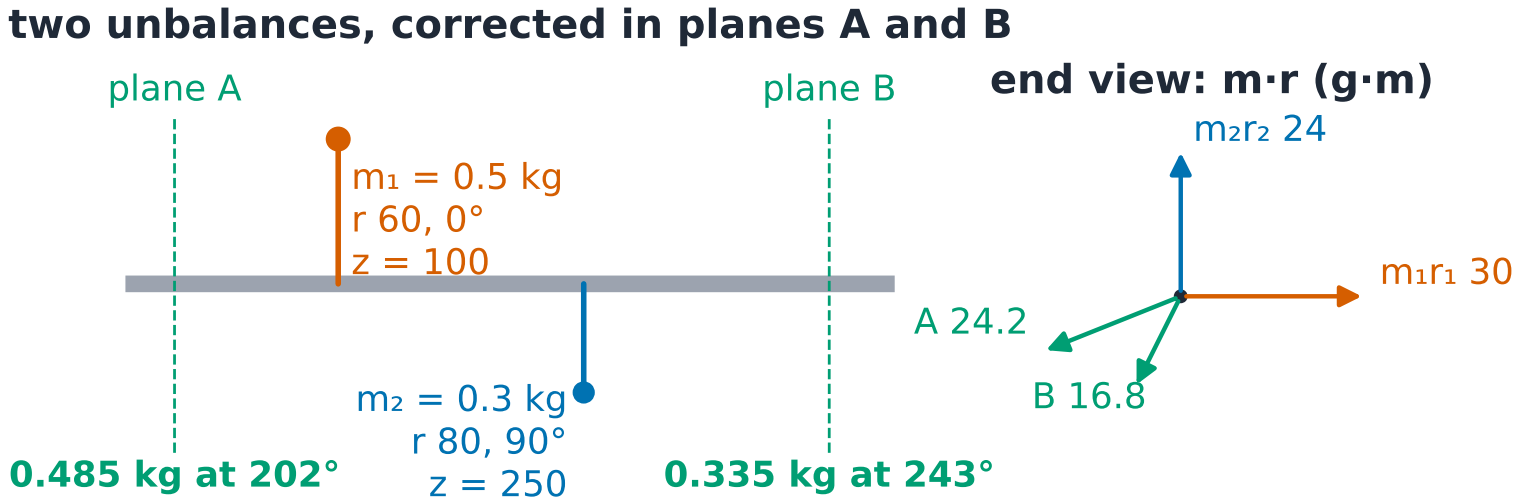
Exercise walk-through

11.3 Balancing

University Mechanical Engineering

Balancing in two planes



Corrections at 50 mm: $\mathbf{0.485}$ kg at $\mathbf{202}°$ in A, $\mathbf{0.335}$ kg at $\mathbf{243}°$ in B; 873 N of shaking removed.

The reciprocating mass

1. **Primary** 0.8 kg, 40 mm, 31.42 rad/s $\rightarrow$ $mr\omega^2 = \mathbf{31.6}$ N, once per turn.
2. **Secondary** $mr\omega^2/n = \mathbf{7.9}$ N, twice per turn.
3. **Half balance** 15.8 N left along the stroke, 15.8 N added across it.

Decision

Partial balance trades a large force in one direction for a smaller one that turns.

Exercises 2.1·2.2

2.1 A rotor carries $m_1 = 0.4$ kg at 50 mm, angle 0°, and $m_2 = 0.6$ kg at 40 mm, angle 120°. Find the resultant $\sum m\mathbf{r}$ as components and its size (two decimals, g · m), and the shaking force at 1200 rpm (one decimal, N). [4]

2.2 A 1.2 kg reciprocating mass runs on a 50 mm crank at 600 rpm with $n = l/r = 4$. Find the primary and secondary force amplitudes (one decimal, N) and the secondary frequency. [3]

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2.1

- $m_1\mathbf{r}_1 = (20, 0)$ g · m; $m_2\mathbf{r}_2 = 24(\cos 120°, \sin 120°) = (-12, 20.78)$ g · m.
- $\sum m\mathbf{r} = (8, 20.78)$ g · m, size **22.27** g · m.
- $\omega = 2\pi N/60 = 2\pi \times 1200/60 = 125.66$ rad/s; $F = mr\omega^2 = 0.02227 \times 125.66^2 =$ **351.7** N.

2.2 A 1.2 kg reciprocating mass runs on a 50 mm crank at 600 rpm with $n = l/r = 4$. Find the primary and secondary force amplitudes (one decimal, N) and the secondary frequency. [3]

2.2

- $\omega = 62.83$ rad/s; primary $mr\omega^2 = 1.2 \times 0.05 \times 62.83^2 =$ **236.9** N.
- Secondary $mr\omega^2/n =$ **59.2** N, at twice the shaft frequency: 20 Hz.

Exercise 3.1

3.1 In 2.1, m_1 sits at $z = 80$ mm and m_2 at $z = 220$ mm. Correction planes are at $z = 0$ (A) and $z = 300$ mm (B), with masses at 60 mm radius. (a) Find $\sum m\mathbf{r}z$ (components, g $\cdot$ m^2). (b) Find the correction in plane B and then in plane A: mass (three decimals, kg) and angle (one decimal, degrees). (c) Explain why one mass opposite the resultant of 2.1 would not do. [9]

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3.1

- (a) $\sum m\mathbf{r}z = (20 \times 0.08 - 12 \times 0.22,\ 20.78 \times 0.22) = (-1.04, 4.573)$ g · m^2.
- (b) $m_B\mathbf{r}_B = -\sum m\mathbf{r}z / z_B = (3.467, -15.24)$ g · m, size 15.63 g · m.
- $m_B = 15.63/60 = \mathbf{0.261}$ kg at $\mathbf{282.8}°$.
- $m_A\mathbf{r}_A = -\sum m\mathbf{r} - m_B\mathbf{r}_B = (-11.47, -5.54)$ g · m, size 12.74 g · m.
- $m_A = 12.74/60 = \mathbf{0.212}$ kg at $\mathbf{205.8}°$.
- (c) A single mass cancels the force but sits in one plane, so the couple $\sum m\mathbf{r}z$ stays and rocks the shaft in its bearings: static balance only.