PHAS1247 Examination 2007
Final answers to unseen problems

1. Reaction at inner wheel $N_1 = \frac{Mg}{2} - \frac{Mv^2h}{RD}$.

   Reaction at outer wheel $N_2 = \frac{Mg}{2} + \frac{Mv^2h}{RD}$.

   Maximum speed $v_{\max} = \sqrt{\frac{gRD}{2h}}$.

2. Speed of wind $3.22\,\mathrm{m\,s^{-1}}$. Speed of athlete $3.71\,\mathrm{m\,s^{-1}}$. Speed of rain relative to athlete $13.86\,\mathrm{m\,s^{-1}}$.

3. No unseen component.

4. Magnitudes of velocities: $v_1 = \frac{\sqrt{3}}{2}u$, $v_2 = \frac{1}{2}u$. Magnitude of impulse $mv_2 = \frac{1}{2}mu$ in each case.

5. New angular velocity $\omega_1 = \frac{4\omega_0}{3}$.

   Work done $\frac{1}{6}I_0\omega_0^2$.

6. Volume flow rate A_1v_1.

   Final velocity $v_2 = \frac{A_1v_1}{A_2}$.

   Pressure difference $\Delta p = \frac{\rho v_1^2(A_1^2 - A_2^2)^2}{A_2^2}$.

7. (a) Range $R = \frac{u_0^2\sin(2\alpha)}{g}$.

   (b) Maximum height $\frac{u_0^2\sin^2\alpha}{2g}$.

   Range must be between $6.32\,\mathrm{m}$ and $29.08\,\mathrm{m}$.

   Angle $\alpha = 22.54°$.

8. Skidding stops after time

$$t_1 = \frac{v_0 I_0}{\mu g(I_0 + MR^2)}.$$

   Speed at this point is

$$v_1 = \frac{MR^2 v_0}{I_0 + MR^2}.$$

9. Set as a problem-sheet question; see model answer to Problem Sheet 3, Question 5.

10. Required moments of inertia are

    (i) $I_A = \frac{49}{12}ML^2$;
    (ii) $I_{AB} = \frac{49}{24}ML^2$;
    (iii) $I_{AC} = \frac{19}{24}ML^2$.

    Angular velocity

$$\omega = \sqrt{\frac{60g(\sqrt{2}-1)}{49L}}.$$

11. For massless rope, ratio of speeds is

$$\frac{v_1}{v_2} = \frac{m_2}{m_1}.$$

Boat 1 moves a distance $\frac{m_2 D}{m_1+m_2}$; boat 2 moves $\frac{m_1 D}{m_1+m_2}$.

For a rope of mass m_3, boat 1 moves $\frac{(m_2+m_3/2)D}{m_1+m_2+m_3}$; boat 2 moves $\frac{(m_1+m_3/2)D}{m_1+m_2+m_3}$.