Chapter 4: Orbital mechanics

1. Show that the deflection angle, δ, of a hyperbolic orbit can also be written

$$\tan\frac{\delta}{2} = \frac{\mu}{bv_\infty^2}$$

2. On page 54 I write, when referring to the parabolic orbit, "its velocity at periapsis is therefore equal to the escape velocity". Is its velocity equal to the escape velocity at any other point in its orbit?

Chapter 7: Relativisitic motion

1. A relativistic rocket accelerates with constant proper acceleration and constant effective exhaust velocity. Derive an expression for how its mass varies with proper time. Compare this to the classical, non-relativistic result.

Chapter 11: Laser sails

1. In section 11.1.1 we started with a simplified argument for the 'double Doppler effect' which gave rise to equation 11.1 for the frequency of the photon reflected from a sail receding at velocity β. Later in that section we do a proper derivation. Using equations 11.3, derive an expression for the frequency of the reflected photon ν_r in terms of the initial sail velocity β_i and the frequency of the emitted (incident) photon ν_e. Show that this leads to a lower frequency than that predicted by equation 11.1 by a factor of

$$1 + \frac{2h\nu_e}{mc^2}\sqrt{\frac{1-\beta_i}{1+\beta_i}}\,.$$

2. (a) At low velocities, a perfectly reflecting sail reflects most of the incident photon energy back to the laser, resulting in a low energy efficiency (see equation 11.1 and figure 11.3). Would a perfectly absorbing sail – which reflects no photons back to the laser – therefore be more efficient and so more preferable? (b) But do we actually want high energy transfer efficiency, or rather high momentum transfer efficiency? After all, at low velocities, photons incident on a perfectly reflecting sail transfer twice as much momentum as those incident on a perfectly absorbing sail (see section 10.1).

Chapter 14: Navigation

1. On page 262 I write "When we have onboard measurement accuracy of 1 mas, then we can determine the ICRF time to within about an hour." How precise do the stellar proper motions have to be for this to hold?

Chapter 15: Communicaton

1. Investigate the variation of the power ratio in equation 15.13 on wavelength for stars of different temperatures. What is the physics behind this variation?

2. Could aliens have detected us? Compute the spectral intensity – intensity per unit frequency, $\mathrm{W\,m^{-2}\,Hz^{-1}}$ – at Proxima Centauri of a 1 kW signal transmitted in the Ka band with a 1 GHz bandwidth from a 100 m-diameter radio telescope on the Earth. How does this compare to the spectral intensity of natural radio sources in the universe as observed from the Earth?