Study notes for Chapter One of *Solar Sailing: Technology, Dynamics, and Mission Applications* by Colin R. McInnes last edit 2016 March 11 MBM

pXXX.YY means page XXX, line YY. Making a guide is useful.

p4.34 "solar sail orbits are …" should be "solar sail orbits can be …"

p9.38 Fig.1.7 See also p72 fig.3.9

p12.16 Fig.1.3 Is sail suspended only from tips of the spars, or is it also draped along the spar? Can a static charge flatten the sail?
A rectangular sail with structure ___/
(center strut = twice end struts) / \ , struts meeting at 120°, has more area per total strut length than a square with struts meeting at 90°, X. A triangle with Y structure also works. If total strut length is 12S, the rectangle has area = $20.8S^2$ compared to $18S^2$ for the simple square. This analysis ignores increased strength needed for longer members.

p12.35 Fig1.9 Can anything be gained by stacking several heliogyros? Shading should be minimal. If they are counter rotating it would cancel angular momentum. This also allows same total area as single heliogyro but with reduced panel length.

p13.21 Sails can rolled around cylinder from outside in. The cylinder would automatically discard hwen sail is finished unrolling.

p13.23 You can also spin a square sail. See IKAROS from Japanese space agency JAXA.

p14.08 In eq.1.1 $\sigma = m/A$, m is mass of sail, structure, and payload.

p14.24 Change "between" to "among".

p15.38 Redraw fig.1.12, more consistent with fig.2.3.

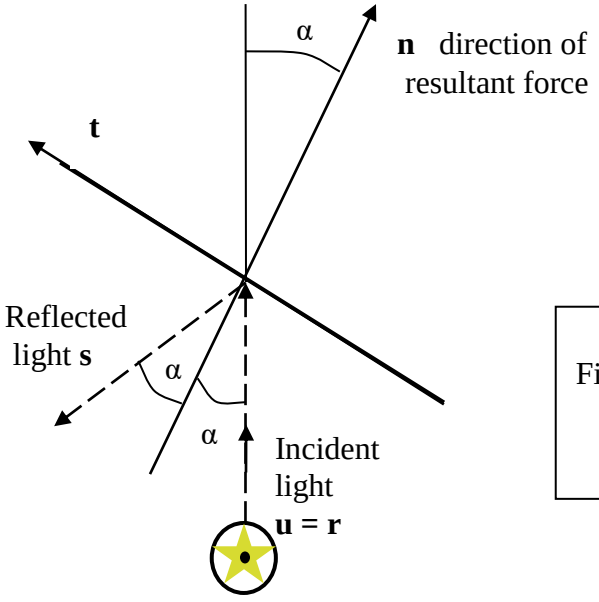

Fig.1.12

ff fig.1.12 et cetera Draw Sol as open circle to indicate light, and use appropriate shading on planets.

p16.22 Fig.1.13 These are not the logarithmic spirals from Chapter 4. Note that the orbits first move outside Terra's circular orbit.

p16.25 "pressure force decreases..." See Robert Forward's solar thruster, p91 and fig.3.23. Is heating of secondary mirror a problem?

p16.41 "continuously altered ..." Can be done with discrete sail settings. See notes to logarithmic spiral in Chapter Four.

p16.43 Velocity matching not necessary if aero braking or rocket matching is used. See sec 1.4.3.

p17.20 Fig.1.14. Again, this is not a logarithmic spiral. See p.135.
If sail is cut loose at arbitrary point of orbit, result will be an ellipse.

p17.28 Specific impulse is an awkward concept as the definition uses the parochial weight on Terra. From I_{sp} = (change of momentum)/(change of weight) and eq.1.2, $m_2 = m_1 \exp(-\Delta v/gI_{sp}) = m_1 \exp(-\Delta v/g[\Delta m v_{exhaust}/\Delta mg]) =$ $m_1 \exp(-\Delta v/[\Delta m v_{exhaust}/\Delta m]) = m_1 \exp(-\Delta v/[v_{exhaust}])$. Assumes $v_{exhaust}$ is constant.

p18.11 and 19 Add brackets to eq.1.13 eq.1.14 $I_{sp} = (\Delta v/g)[\ln(1/R)]^{-1}$ and $I_{sp} \sim (a_0 T/g)[\ln(1/R)]^{-1}$

p19.19 Fi.1.15 From top to bottom, label the dashed lines 3370, 2200, 450, 200.

p19.44 "begin from altitudes", change to "begin from minimum altitudes"

p20.25 Fig. 1.16 is travel time starting at 1 au but not orbiting Terra. The travel time can be anyhwere between the maximum and minimum curves depending on planetary positions at departure.

p20.40 A Keplerian orbit is one with no forces other than gravity.

p21.14 "crank" means to change orbit inclination.

p21.26 "13 km s^{-1} ". For the Hohmann transfer I get Δv departing orbit at 1 au of 7.53 km/s and Δv going into circular orbit at Mercury's 0.387 au of 9.62 km/s, total Δv equal 17 km/s.

p22.43 The payload to total mass ratio is larger than the 1/3 deemed typical elsehwere. Do the 4.2 years and 2.0 years allow for meeting Terra upon return?

p23.01 How do you reload the returning sail at 1 au? Has it matched Terra's circular orbit?

p23.15 Hyperbolic excess velocity is the speed a spacecraft has at (approximate) infinite distance relative to some body.
$V_\infty^2 = (\mu/-a) = v^2 - v_{esc}^2 = v^2 - 2v_{cir}^2$. The (-a) means the spacecraft is on a hyperbola and not another conic section.

p23.32 "local gravitational acceleration can be of the same order as" the local sail acceleration. True at some distance for planets as well.

p24.29 "displace <u>circular</u> sun-centered orbits". If not circular the orbit does not become an ellipse but becomes non-planer and complicated.

p24.36ff Robert Forward, L_1, Statite. Displace artificial L_1 off of Sol-Terra line to reduce interference from solar radiation.