SOLUTION SET 2
Physics 2022

1. $d = c\,t = (3 \times 10^5 \text{ km/s})\,(4 \text{ hr})\,(3600 \text{ s/hr}) = 4.3 \times 10^9 \text{ km}$

2. $c = f\lambda$

$f = c / \lambda = (3 \times 10^8 \text{ m/s}) / (0.4 \text{ m}) = 7.5 \times 10^8 \text{ Hz}$ **Radio**

3. $c = f\lambda$

$\lambda = c / f = (3 \times 10^8 \text{ m/s}) / (3 \times 10^{16} \text{ /s}) = 1 \times 10^{-8} \text{ m} = 10 \text{ nm}$ **X-ray**

4. $F_s \propto 1 / d_s^2 \qquad F_e \propto 1 / d_e^2$

$F_s / F_e = d_e^2 / d_s^2 = (1 / 10)^2 = 0.01$ times as strong

5. $F_{sc} \propto 1 / d_{sc}^2 \qquad F_e \propto 1 / d_e^2$

$F_{sc} / F_e = d_e^2 / d_s^2 = 20$

$d_e / d_{sc} = 4.5 \qquad d_{sc} = 0.22\, d_e = 0.22$ AU

6. $T_F = 98.6^o$

$T_K = 5/9\,(98.6 - 32.0) + 273 = 5/9\,(66.6) + 273 = 36.7 + 273 = 309.7$ K

$\lambda_{max} = 0.0029 / T_K = 0.0029 / 309.7 = 9.36 \times 10^{-6} \text{ m} = 9.36\ \mu\text{m}$ **IR**

7. $T = 5800$ K

$T_F = 9/5\,(5800 - 273) + 32 = 9/5\,(66.6) + 32 = 9949 + 32 = 9981^o$ F

$\approx 10{,}000^o$ F

8. $T_{altair} = 21{,}600$ K $\qquad T_{sun} = 5800$ K

$F_{altair} / F_{sun} = (21{,}600 / 5800)^4 = (3.72)^4 = 192$ X

9a. $T_1 = 320^oC = 320 + 273 = 593\ K$

$\lambda_{max} = 0.0029 / T_1 = 0.0029 / 593 = 4.89 \times 10^{-6}\ m = 4{,}890\ nm$ (IR)

9b. $T_2 = -150^oC = -150 + 273 = 123\ K$

$E_2 / E_1 = (T_2)^4 / (T_1)^4 = (T_2 / T_1)^4$

$= (593 / 123)^4 = (4.82)^4 = 540$

10. $L_{sirius} / L_{sun} = (R_{sirius} / R_{sun})^2 (T_{sirius} / T_{sun})^4$

$25 = (1.67)^2 (T_{sirius} / T_{sun})^4 = (1.67)^2 (T_{sirius} / 5800)^4$

$T_{sirius} = 10{,}030\ K$

11. $E_A = hf_A \quad E_B = hf_B \quad f_A = 2f_B$

$E_A / E_B = hf_A / hf_B = 2f_B / f_B = 2 \quad E_A = 2 E_B$

12. $\Delta\lambda / \lambda = v / c$

$(486.112 - 486.133) / 486.133 = v / (3 \times 10^5\ km/s) \quad v = -13.0\ km/s$

Toward us -- the observed wavelength is shorter (bluer) than the rest wavelength.

13. $\lambda_{obs} = 20.02\ cm \quad \lambda = 20\ cm$

Observed wavelength is longer than rest wavelength, therefore it is red-shifted.

$v / c = \Delta\lambda / \lambda = (\lambda_{obs} - \lambda) / \lambda = (20.02 - 20.00) / 20.00 = 10^{-3}$

$v = (10^{-3}) (3 \times 10^5\ km/s) = 300\ km/s$

14. $v = -20{,}000\ km/s \quad \lambda = 500\ nm$

$v / c = \Delta\lambda / \lambda = (\lambda_{obs} - \lambda) / \lambda$

$(-20{,}000\ km/s) / (3 \times 10^5\ km/s) = (\lambda_{obs} - 500\ nm) / 500\ nm$

$(\lambda_{obs} - 500\ nm) = -33.3\ nm \quad \lambda_{obs} = 466.7\ nm$

15. $\Delta\lambda / \lambda = v / c$ **(500 – 700) / 700 = v / (3 x 10^5 km/s)**

v = -85,700 km/s (approaching)