SOLUTION SET 4
Physics 2022

1. $d = 1.496 \times 10^8$ km / 9.46×10^{12} km/ly = 1.58×10^{-5} ly

No − too small

2. d_{pluto} = 39.5 AU / 206,265 AU/pc = 1.92×10^{-4} pc $\quad$ d_{prox_c} = 1.30 pc

d_{prox_c} / d_{pluto} = 1.30 / (1.92×10^{-4}) = 6790

3a. d = (2×10^6 AU) / (206,265 AU/pc) = 9.7 pc

3b. p″ = 1 / d = 1 / 9.7 pc = 0.10 arcsec **YES**

4. p″ = 0.153 arcsec $\quad$ d = 1 / p″ = 1 / 0.153″ = 6.54 pc

5a. $v_T = 4.74\ \mu / p$ = 4.74 (8.67 arcsec/yr) / (0.255 arcsec) = 161 km/s

5b. $v = \text{sqrt}\,[\, v_T^2 + v_r^2 \,]$ = sqrt [$(161)^2 + (246)^2$] = 294 km/s

5c. Because the velocity is positive, it is moving away from the Sun.

6a. $v_T = 4.74\ \mu\ d$ $\quad$ d = (40 km/s) / [4.74 x 0.08] = 106 pc

6b. $v_T = 4.74\ \mu\ d$ = (4.74) (10.358 arcsec/yr) (106 pc) = 5.2×10^3 km/s

The star needs a tangential velocity of about 5200 km/s to exhibit a proper motion equal to that of Barnard's star.

7. $v^2 = v_T^2 + v_r^2$ $\quad$ $v_T^2 = (120)^2 - (48)^2$ $\quad$ v_T = 110 km/s

8a. $\Delta \lambda / \lambda = v / c$

v = [(656.41 – 656.28) / 656.28] (3×10^5 km/s) = 59 km/s

8b. Redshifted (i.e., positive), therefore it is receding from us.

9. $b_A = b_B$ $d_A = 12$ pc $d_B = 48$ pc

$L_A / L_B = (d_A / d_B)^2 (b_A / b_B) = (12 / 48)^2 (1 / 1) = 0.062$ **(B has greater luminosity)**

(Square the ratio of the distances – Inverse Square Law)

10. $L_C = L_D$ $d_C = 60$ pc $d_D = 12$ pc

$L_C / L_D = (d_C / d_D)^2 (b_C / b_D) = (60 / 12)^2 (b_C / b_D) = (1 / 1)$

$b_C / b_D = 1 / 25$ $b_D = 25\, b_C$ **(D is brighter)**

(Square the ratio of the distances – Inverse Square Law)

11. $b_1 = b_2$ $d_1 / d_2 = 9$

$L_1 / L_2 = (d_1 / d_2)^2 (b_1 / b_1) = (9)^2 (1 / 1) = 81$ **(Farther star is more luminous)**

12. $L_{initial} = L_{final}$ $b_{initial} = 1370\ W/m^2$ $b_{final} = 1\ W/m^2$ $d_{initial} = 1$ AU

$L_{final} / L_{initial} = (d_{final} / d_{initial})^2 (b_{final} / b_{initial}) = (1 / 1) = (d_{final} / d_{initial})^2 (1 / 1370)$

$d_{final} =$ sqrt[1370] = 37 AU

13. $\Delta m = 1.8 = 2.5 \log (F_2 / F_1)$

$\log (F_2 / F_1) = 0.72$

$F_2 / F_1 = 10^{0.72} = 5.2$

14. $d_{initial} = 2.97$ pc $b_{final} / b_{initial} = 60$

$L_{final} / L_{initial} = (d_{final} / d_{initial})^2 (b_{final} / b_{initial}) = (1 / 1) = (d_{final} / d_{initial})^2 (60)$

$d_{final} =$ sqrt[1 / 60] x 2.97 pc = 0.38 pc = 79,000 AU

$d_{pluto} = 40$ AU **Therefore distance ratio about 2000 X**

15a. $m – M = 5 \log (d / 10)$ $d = 1 / p = 1 / 0.222 = 4.5$ pc

$12.1 – M = 5 \log (4.5 / 10) = -1.7$

$M = 12.1 + 1.7 = 13.8$ mag

15b. $M_{sun} = 4.8$ mag

$\Delta M = 4.8 - 13.8 = 2.5 \log (L_K / L_{sun})$

$L_K = 2.51 \times 10^{-4} L_{sun}$

16. Area 1 / Area 2 = $(60\text{-in} / 6\text{-in})^2 = 100$

A ratio of 100 corresponds to a $\Delta m = 5$ mags

$m = 12 + 5 = 17$ mags

17. $m - M = 5 \log (d / 10)$

$14.0 - 0.0 = 5 \log (d / 10)$

$d = 6310$ pc

18. $\Delta m = m_1 - m_2 = 2.5 \log (F_2 / F_1)$

18a.	$2.9 - m_2 = 2.5 \log (246)$	$m_2 = -3.1$
18b.	$3.1 - (-0.2) = 2.5 \log (F_2 / F_1)$	$F_2 / F_1 = 20.9$
18c.	$m_1 - 12.4 = 2.5 \log (46)$	$m_1 = 16.6$
18d.	$-1.4 - (0.5) = 2.5 \log (F_2 / F_1)$	$F_2 / F_1 = 0.2$

19. $m - M = 5 \log (d / 10)$

19a.	$6.8 - 3.3 = 5 \log (d / 10)$	$d = 50.1$ pc
19b.	$3.3 - 6.8 = 5 \log (d / 10)$	$d = 2.0$ pc
19c.	$9.7 - M = 5 \log (32 / 10)$	$M = 7.2$
19d.	$7.7 - (-5.4) = 5 \log (d / 10)$	$d = 4{,}169$ pc