SHORT ANSWER. Answer the question(s), showing the work of any computations needed.

41) a. (2 points) An object of mass 1 kg falls in the earth's gravitational acceleration of about 10 m/s². Neglecting air resistance, and starting from rest, what is its speed after 5 seconds?

\[ v = g \times t = 10 \text{ m/s} \times 5 \text{ s} = 50 \text{ m/s} \]

b. (2 points) How would this change if the object had a mass of 2 kg?

It wouldn't because gravitational acceleration doesn't depend on mass.
42) (4 points) Consider two telescopes with diameters $D_1 = 1$ m and $D_2 = 5$ m.

a. What is the ratio of the telescope areas, $A_2/A_1$?

$$A = \frac{\pi}{4} D^2 \Rightarrow \frac{A_2}{A_1} = \left(\frac{D_2}{D_1}\right)^2 = \left(\frac{5}{1}\right)^2 = 25 = \frac{A_2}{A_1}$$

b. What is the ratio $a_2/a_1$ of the smallest angle that can be resolved?

$$a \sim \frac{1}{D} \Rightarrow \frac{a_2}{a_1} = \left(\frac{D_1}{D_2}\right) = \frac{1}{5} = \frac{a_2}{a_1}$$

43) A star has a surface temperature that is twice that of the sun, but the same radius.

a. (2 points) In terms of the solar luminosity $L_{\text{sun}}$, what is the star's luminosity $L$ (i.e. total energy output per unit time)?
43) A star has a surface temperature that is twice that of the sun, but the same radius.

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$$\frac{L}{L_{\text{sun}}} = \left(\frac{R}{R_{\text{sun}}}\right)^2 \left(\frac{T}{T_{\text{sun}}}\right)^4 = 1^2 \left(\frac{2}{1}\right)^4 = 16 \Rightarrow \frac{L}{L_{\text{sun}}} = 16$$

b. (2 points) Recalling that the sun has its spectral energy peak at a wavelength of about 500 nm, what would be the wavelength of peak energy of this star?

$$\lambda_{\text{peak}} = 500 \text{ nm} \left(\frac{T_{\text{sun}}}{T}\right)^{\frac{1}{2}} = 500 \left(\frac{1}{2}\right)^{\frac{1}{2}} \text{ nm} = 250 \text{ nm} = \lambda_{\text{peak}}$$
44) (3 points) A planet orbits a star with mass of 2 times the solar mass at a distance of 2 AU. In earth years, about how often would beings on this planet celebrate birthdays?

\[
\frac{M + m}{M_{\text{Sun}}} = \left(\frac{a}{2\text{AU}}\right)^3 = \frac{M}{M_{\text{Sun}}} \implies \frac{a}{2\text{AU}} = \sqrt[3]{(\frac{P}{\text{yr}})^2} \implies \frac{P}{\text{yr}} = z^2
\]

\[
P = 2\text{yr}
\]

\[\implies \text{every two } \text{earth years}\]

45) A spectral line that normally has a wavelength of 600 nm in the laboratory is observed to be Doppler shifted to a wavelength of 599.8 nm in the spectrum of a star.

a. (1 point) Is the star moving toward or away from the observer?
A spectral line that normally has a wavelength of 600 nm in the laboratory is observed to be Doppler-shifted to a wavelength of 599.8 nm in the spectrum of a star.

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\[ \text{Eqn. 18} = \frac{\lambda_{\text{obs}}}{\lambda} < 1 = \frac{600}{600} \Rightarrow \text{moving away} \]

b. (2 points) What fraction of the speed of light is this star moving?

\[ \frac{V}{C} = \frac{\lambda_{\text{obs}} - \lambda}{\lambda} = \frac{599.8 - 600}{600} = -0.2 = \frac{1}{3000} = \frac{V}{C} \]

c. (2 points) Given that the speed of light is 300,000 km/s, compute the star's speed in km/s.

\[ V = \frac{C}{3000} = \frac{300,000 \text{ km/s}}{3} = 100 \text{ km/s} \]