IB Physics
PreQuiz 33.1

Name Example

Funniest Moment in Class

1. A star has a Luminosity of 4.5 x 10^{26} W, and a peak black body radiation of 520 nm. What is its radius? (8.08 x 10^8 m)

$T = \frac{2.90E-3}{\lambda}$

$T = \frac{2.90E-3}{520E-9} = 5576.92$ K

$L = \sigma A T^4$

$4.5E26 = (5.67E-8)4\pi r^2 (5576.92)^4$

$r = 8.08017$ E8 m

2. A star has an apparent brightness of 2.35×10^{-14}W/m^2. If it has an absolute magnitude of 2.3, how many parsecs are we from it? (3590 -> 3600 pc)

$m = 2.5 \log\left(\frac{2.52E-8}{2.35E-14}\right) = 15.0758$

$m - M = 5\log\left(\frac{d}{10}\right)$

$15.0758 - 2.3 = 5\log\left(\frac{d}{10}\right)$

$10\left(10^{\left(\frac{m-M}{5}\right)}\right) = 3590.59$ pc

3. A galaxy is 23 Mpc from us. At what wavelength would we see the 486 nm spectral line or Murrayium from that galaxy. (Use H = 50 km/s/Mpc) (487.863 -> 488 nm)

$v = Hd$

$v = \left(50 \frac{km/s}{Mpc}\right)(23\ Mpc) = 1150 \frac{km}{s}$

$\frac{\Delta v}{c} = \frac{\Delta\lambda}{\lambda}$

$\frac{1150 \frac{km}{s}}{3E5 \frac{km}{s}} = \frac{\Delta\lambda}{486}$

$\Delta\lambda = 1.863$

so

$\lambda' = 486 + 1.863$

487.863 nm

4. A very strong concertmaster is on top of a 148 m tall tower near a black hole where the gravitational field strength is 5.53×10^{12} m/s/s. If another player is making a frequency of 440.0 Hz at the bottom, what frequency does the concertmaster hear at the top? What beat frequency do they hear? (436. Hz, and 4.00 beats per second)

$\frac{g\Delta h}{c^2} = \frac{\Delta f}{f}$

$\frac{(5.53E12)(148)}{(3E8)^2} = \frac{\Delta f}{440}$

$\Delta f = 4.00$ Hz

Low clocks run slow so the concertmaster hears $440 - 4 = 436.0$ Hz

and this beats $f = |440 - 436| = 4.00 \frac{beats}{sec}$

5. A black hole has a mass of 21 solar masses. (The mass of the sun is 1.99×10^{30} kg.) *Calculate the radius of the event horizon, *Calculate the time it would take a clock 160 km beyond the event horizon to register 60. seconds of elapsed time as we observe it from a great distance. (62 km, 71 s)

$R_s = \frac{2GM}{c^2} = \frac{2(6.67E-11)(21)(1.99E30)}{(3E8)^2} = 61942.1$ m

$\Delta t = \frac{\Delta t_0}{\sqrt{1 - \frac{R_s}{r}}} = \frac{60s}{\sqrt{1 - \frac{61942.1}{(160{,}000 + 61942.1)}}} = 70.666$ s