PHYSICS 313 - Winter/Spring Semester 2017 - ODU

Astrophysics - Problem Set 1 – DUE THURSday, January 19

GENERAL INSTRUCTIONS:
Please submit your solution using the following format. You can submit it as an email to skuhn@odu.edu anytime before midnight on the day on which the Problem Set is due; in this case, you **must** use an electronic file format (like MS Word, LaTeX, .pdf, Mathematica etc.) or simple text (follow the rules of some programming language like Fortran or C to write mathematical expressions like x**2 for the square of *x* etc.). Alternatively, you can write your solution by hand on paper and turn it in **in class** on the same day (no late submissions); please write clearly and cleanly!

For each problem (part), type the problem number (e.g., "1a." or "2c"), followed by a space, and then your solution. For "yes/no" questions, enter "Y" or "N", for multiple choice questions, enter the correct choices ("1" or "3" or…) without any additional characters, and for numerical questions, quote the result in the form "3.1415" or "3.1415e12". For conceptual questions, just write the text (no special formatting needed). Some problems require mathematical derivations or equations in addition to text or numbers (clearly stated in the problem text). **Only** for those cases may you use a **clean** scanned image of a handwritten derivation, included in your electronic submission (if you choose that route).

IN ALL CASES, make sure that your full name appears on all your submissions to guarantee you get credit for your work! Also, do NOT simply copy someone else's solution (honor code!) – you can ask for help if you get stuck, but you must submit your OWN work. (I will randomly ask questions during class to check whether you understand the solution you submitted).

Problem 1

Please answer the following questions with "Y" or "N":

1a) Is there any fundamental difference between the infrared "light" emitted by a warm object (e.g. a hot cookpot) and the x-rays used by a dentist, apart from their frequencies?
1b) The apparent magnitude m of a star at 10 parsec distance is the same as its absolute magnitude M. True?
1c) If you double the distance to some star, it's apparent magnitude m will also double. True?
1d) In the absence of any external influences, any closed orbit of a satellite around a massive body is an ellipse. True?
1e) Kepler's Law about the "radius vector sweeping out equal areas in equal times" applies **only** for gravitational attraction, no other interactions. True?
1f) The virial theorem states that the kinetic energy of the solar system (due to the motion of all its parts) is equal to twice its potential energy (due to all gravitational attraction between its parts). True?

PHYSICS 313 - Winter/Spring Semester 2017 - ODU

Problem 2

The following is a set of multiple choice questions. Answer each with **one single** digit:

2a) Which of the following properties does NOT distinguish between different types of electromagnetic plane waves in vacuum?

1 – Their different frequencies or wavelengths
2 – Their different phase velocities
3 – Their direction of propagation
4 – Their direction of polarization

2b) Compare the radiation emitted by the surface of a very hot star (13,000 K) with that from the surface of a colder one (3600 K). Which statement is correct?:

1 – Both stars emit visible light.
2 – The hot star appears much more reddish to the eye than the colder one.
3 – Both stars emit about the same amount of energy per unit time and surface area
4 – The hot star emits no infrared ($\lambda > 800$ nm) radiation.

Problem 3

For the following, assume a star is at a distance of 20 parsec from Earth. Calculate the following (only numbers and units are needed, but show your work for partial credit):

3a) By how much (what angle) does the apparent direction (relative to the fixed background of faraway stars) to this star change over exactly half a year?
3b) If the star has the same luminosity as Sun, what is its **absolute** magnitude M?
3c) What is its **apparent** magnitude m?
3d) How far away would a 100 W light bulb have to be to have the same apparent brightness (magnitude) as this star? (Assume the light bulb emits 100 W of light – while of course a "real" 100 W light bulb would emit much less – the 100 W would usually refer to the electricity consumption).

Note: $L_{sun} = 3.84 \cdot 10^{26}$ W, $m_{sun} = -26.74$, $M_{sun} = +4.83$ and $m_2 - m_1 = 2.5 \lg(F_1/F_2)$ with $F = \dfrac{L}{4\pi r^2}$

Problem 4

The International Space Station has a mass of $m = 420{,}000$ kg and orbits planet Earth 250 km above its surface. Calculate the following numbers:

4a) Assuming a circular orbit, what is the speed of the space station?
4b) What is its kinetic energy?
4c) What is its potential energy?
4d) What is its total mechanical energy?
4e) How much energy was needed to lift it from rest on Earth's surface to its present orbit?

You may ignore all other celestial bodies. Set the potential gravitational energy of Earth to zero at infinite distance.