ASTRONOMY 1102 – 1

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Answers to HW2, Fall 1999

1) I am giving the radii here; the diameters will be twice that. a) Sun: 7×10^5 km; b) Solar System: 40 AU; c) To α Cen or Proxima Centauri: 4.2 LY; d) Radius of Milky Way: 45,000 LY or 15 kpc; e) Local Group: 2.5 million LY, or O.7 Mpc; f) Local Supercluster: 50 million LY, or 15 Mpc.

2) Oxygen has atomic number 8, i.e. 8 protons, so when neutral it must have also 8 electrons. Doubly ionized means two electrons missing, so there are 6 electrons left. The mass number of this isotope is 18 so there must be 10 neutrons in the nucleus. The symbol is

$$^{18}O_8^{++} \quad \text{or} \quad ^{18}O_8^{+2}$$

3) First chemical potential energy in the muscles is converted to kinetic energy of motion of the arm and ball. When the ball is released it has kinetic energy (K.E.); as it ascends the K.E. is converted into gravitational potential energy and a little goes into air turbulence (another form of K.E. but in the surrounding medium). When it reaches its highest altitude, the K.E. is zero and what's left is gravitational potential energy. As it descends the gravitational potential energy is converted into K.E. of the ball and again a little goes into air turbulence. The highest speed and therefore K.E. is reached just as the ball hits the ground. At that point (maybe after some bounces) the energy is lost as deformation of the soil and heat.

4) Careful and objective *observations* lead to a *hypothesis* to explain the observations. On the basis of the hypothesis *predictions* are made which are then subjected to objective *experiments and observations* to confirm or falsify predictions. If hypothesis survives many tests it becomes a *theory*.
Newtonian theory survived about 300 years the test of time. In fact it still a *very good* theory that can be used to calculate orbits of spacecraft and almost all terrestrial applications. *But* it fails in strong gravitational fields, and has a measurable effect also in high precision measurements of astronomical phenomena such as the advance of Mercury's perihelion. Einstein's General Relativity (GR) is better because in striong fields it makes accurate predictions and in weak fields it agrees with Newton. So GR accounts for *all* the phenomena accurately described by Newtonian gravity plus *additional* situations in which Newtonian theory gives an incorrect answer.

5) The density of air is much less than the density of water, so the rate at which your atoms & molecules lose energy by colliding with air molecules is much less than the rate of loss in water. The energy exchange rate with air is therefore *slower* than in water: you cool slowly and your metabolism can make up for the losses. In water you lose energy and freeze faster (recall the Titanic).

6) Material waves need a *medium*, a material through which they can propagate. No medium: no waves, so they cannot propagate through empty space. The light from distant stars obviously has no problem reaching us through empty space, so electromagnetic waves (EMW) are NOT material waves, they are "field" waves. Examples of material waves: sound (air), ocean waves (water), seismic waves (earth's crust and mantle). Examples of photons or EMW: radio waves, visible light, X-rays, etc.

7) NOTE: The wavelength of a 100kHz EMW is *actually* 3 km as you can yourself verify using $\lambda = c/f$.
The object here is to realize simply that λ and f are *inversely* proportional to one another: doubling one halves the other and so on. So, if 100 kHz gives $\lambda = 1km$, a 1MHz EMW (10 times higher than 100 kHz) must have a wavelength to times *shorter* or 0.1 km. So what would it be really, with the typo described in the note above corrected?

8) N is the chemical symbol for Nitrogen.
a) If I look directly at the filament I see a continuous blackbody spectrum corresponding to thermal emission at the temperature of the filament.
b) Looking through the cloud I see an absorption spectrum of Nitrogen (a continuous filament spectrum with dark lines at those wavelengths that the N can emit or absorb radiation).
c) Looking at the cloud directly without seeing the filament at the same time, I see an emission spectrum of Nitrogen (bright lines at the wavelengths N emits).
Please refer to Fig. 7.13 on page 173.