1.

Velocity is a vector quantity, containing information about direction as well as speed, which is the scalar amplitude of velocity.

2.

Parallax is the apparent angular displacement of nearby objects with respect to more distant ones as a consequence of the motion of the observer. The Ancients recognized that if the Earth were orbiting the Sun, then one should observe parallax for some stars. This effect was not observed for many centuries, arguing in favor of the geocentric world model.

3. Kepler's Laws:

1. The orbits of the planets are ellipses with the sun at one focus.

2. A line connecting the sun and a planet sweeps out equal areas in equal times.

3. $P^2 = a^3$ [P in years; a in AU]
where P is the sidereal period of the orbit and a is the semi-major axis of the elliptical orbit.

4. Lunar Eclipse:

In order to observe a lunar eclipse,

1. The phase of the moon must be full;

2. The moon must be near one of the two nodes of its orbit so that it is in the ecliptic plane;

3. The observer must be on the right side (the night side) of the planet when the eclipse occurs.

5. When the moon is past full, you are more likely to see it in the morning — it has set by afternoon.

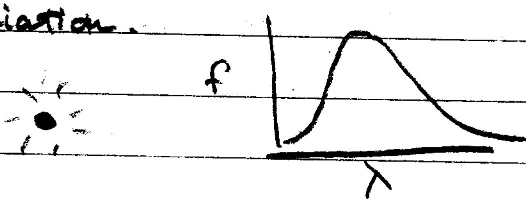
[Anybody look up this morning?]

6.

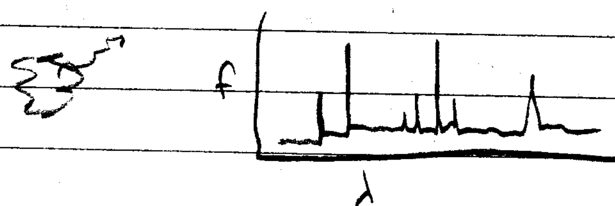
Orbital shape		Energy	
Ellipse		$E<0$	negative energy (bound)
Parabola		$E=0$	marginally unbound
Hyperbola		$E>0$	positive energy (unbound)

7. Kirschoff's Laws:

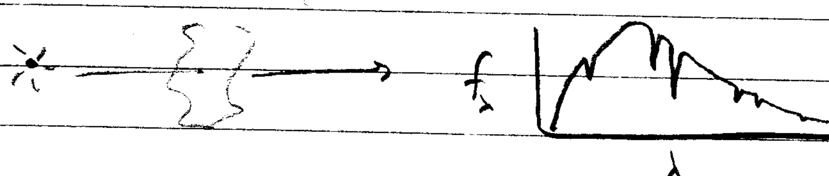
i) A hot, dense object emits a continuum radiation.



ii) A hot, diffuse gas emits an emission line spectrum.



iii) A cool gas obscuring a continuum source results in an absorption spectrum



8. The sidereal year is the period it takes the earth to orbit once around the sun. The tropical year is the period it takes for the seasons to repeat. These are slightly different (by a few minutes) because of precession. This causes the tip of the Earth's axis to be in a slightly different orientation each sidereal year.

9. Comet SL9

$r_{closest} = 6 R_J$ $\qquad$ $R_J = 71{,}500$ km

i)

$$F = \frac{GMm}{r^2}$$ gravitational force

$$\delta F = \frac{2GMmd}{r^3}$$ tidal force

$$\frac{\delta F}{F} = \frac{1}{30{,}000}$$ given

$$\frac{\delta F}{F} = \frac{2\cancel{GMm}d}{r^{\cancel{3}}} \frac{\cancel{r^2}}{\cancel{GMm}} = \frac{2d}{r} \qquad r = 6R_J$$

$$\frac{\delta F}{F} = \frac{2d}{6R_J} = \frac{d}{3R_J} = \frac{1}{30{,}000}$$

$$d = \frac{R_J}{10{,}000} \rightarrow \boxed{d = 7.15 \text{ km}}$$ diameter

$R_{comet} \simeq 3.6$ km

ii) That such a feeble tidal force sufficed to disrupt the comet suggests that its internal material strength was not great.
[You wouldn't crumble in this situation!]

10. Vulcan

$S = 20^d$

i) Vulcan would be an Inferior planet.
($S < 1\,yr$).

ii) To get a, we can use $P^2 = a^3$ and the relation between synodic period S and sidereal period P.
For an inferior planet,

$$P = \frac{S}{1+S}$$ ... must be in years!

$S = 20^d / 365.25\ ^d/_{yr} = 0.055\,yr$

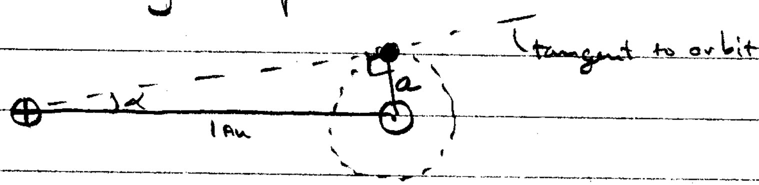
$$P = \frac{0.055}{1.055} = \underline{0.052\ yr}$$

$P^2 = a^3$

$a = P^{2/3} = (0.052)^{2/3}$

$$\boxed{a = 0.14\ AU}$$

10. (con.) iii) Maximum elongation is the angle of separation of an inferior planet from the sun on the sky when it is as far away as possible:



$$\sin\alpha = \frac{a}{a_\oplus} = \frac{0.14\ \text{AU}}{1\ \text{AU}}$$

$$\boxed{\alpha = 8^\circ}$$

iv) With $a = 0.14$ AU, Vulcan would be closer to the sun than Mercury (already hard to observe). With a maximum elongation of only 8°, Vulcan would always be very close to the sun and lost in its glare. Searches were attempted during solar eclipses, and people also watched for transits, it was so hard to spot directly.

11. Sun & Sirius

$\hookrightarrow$ $T = 10{,}000\ K$

i) Wien's Law:

$$\lambda_p T = 2.9\times10^{-3}\ Km$$

$$\lambda_p = \frac{2.9\times10^{-3}\ Km}{10^4\ K}$$

$$\boxed{\lambda_p = 0.29\ \mu m} = 2900\ \text{Å} = 2.9\times10^{-7}\ m$$

ii) This falls in the ultraviolet portion of electromagnetic radiation.

iii) Stefan-Boltzmann rel'n

$$L = 4\pi\sigma R^2 T^4$$

Only ask here about light per unit area

$$F \propto T^4$$

$$\frac{F_{Sirius}}{F_{sun}} = \left(\frac{10\,000}{5800}\right)^4 = 1.72^4$$

$$\boxed{\frac{F_{Sirius}}{F_{sun}} = 8.8}$$

Each square meter of Sirius emits 8.8 times as much energy as the sun.

iv) If Sirius is actually 10 times brighter than the sun, then the temperature difference explains most, but not all, of this difference. That $10 > 8.8$ implies that Sirius is a little larger than the sun (it has a greater surface area $4\pi R^2$).