1. (6 points, 3 for each answer)

Planets are easier to detect around low mass stars because a planet with a given mass causes a star with a lower mass to move more quickly than one with a higher mass. This can be seen using the momentum-conservation equation $V_* = M_p V_p / M_*$. As M_* decreases, V_* must increase, and that makes the changes in the star's radial velocity easier to observe.

Planets with small orbits are easier to detect because they have higher velocities than planets further away. Since V_p increases, V_* increases, and the star's radial velocity is then easier to observe.

2. (4 points): A larger planet blocks more light from the star during transit. The depth of the eclipse tells you what fraction of the star's light is blocked by the planet, which indicates the relative size of the planet and the star; from this, one can derive their relative radii assuming that both are circular in cross-section. Knowing their relative radii gives the radius of the planet if you know the radius of the star through other means. [The star's radius can be obtained through stellar models, but knowing this was not part of the question].

There was one point for each of the following:

a) Transits were used to measure the radius.

b) Bigger planets block more light.

c) The observational consequence of this is that a deeper eclipse indicates a larger planet, and so the depth of the eclipse is used to determine the radius.

d) This process gives the relative radius of star and planet, so to get the actual radius of the planet one must also know the radius of the star.

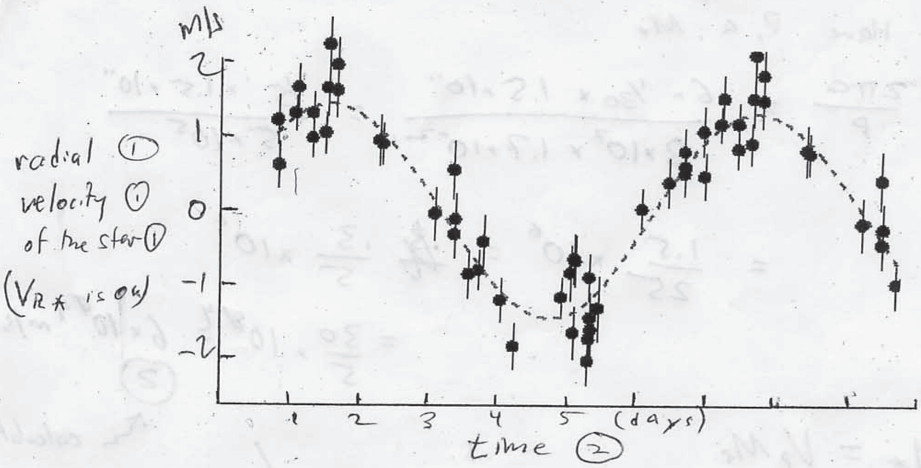
3. (4 points): The composition of the atmosphere is determined by comparing the spectrum of the star while the planet is transiting to the spectrum of the star while the planet is not transiting. When the planet transits, some light from the star passes through the atmosphere of the planet, producing additional spectral features in the planet's spectrum. The atmosphere will absorb light at certain wavelengths, which indicate its composition since each molecule and element absorbs at known wavelengths.

Points were as follows: 2 points for understanding that it is necessary to compare the spectrum during transit and out of transit, since we must see *additional* lines which appear during transit, along with the many which appear in the star even without the planet. 1 point for stating that absorption lines appear because some of the light passes through the atmosphere. 1 point for stating that spectral features indicate composition.

5. Scanned solution on next pages:

NAME: BAILYN

16/16



5 (16 points): The plot above is the radial velocity curve observed by the Anheuser-Busch team. You'll notice that the axes are not labelled. Please label them. In particular, put in the quantities that are being plotted. Be specific — don't just say "distance", but "distance between the planet and the star" etc (that's *not* the right answer for either axis, by the way). Then put in numerical values with appropriate units for the tick marks. To do this you'll need to do some calculations based on information presented in the fake news article. Please carry out the calculations in the space below, and continue on the other side of the paper if necessary.

$a^3 \approx P^2 M$ (1) ~ for knowing P is right thing to calculate and writing down eq^n

$a = 1/30\ AU = 3\times10^{-2}\ AU$

$M = 0.1 M_\odot$

$(3\times10^{-2})^3 \approx P^2\ 10^{-1}$

$\frac{30\times10^{-6}}{10^{-1}} \approx P^2$

$3\times10^{-4} \approx P^2$

$1.7\times10^{-2} \approx P$ (in years) (2) ~ correct calculation

$1\ yr \sim 400$ days

$1.7\times10^{-2} \times 400 = 6$ days $= P$

tick marks are 1 day (1) ~ for putting correctly on axis

Need radial velocity of Star

Have P, a, M_*

1 $V = \frac{2\pi a}{P} = \frac{6 \times 1/30 \times 1.5 \times 10^{11}}{3 \times 10^7 \times 1.7 \times 10^{-2}} = \frac{1/5 \times 1.5 \times 10^{11}}{5 \times 10^5}$

equation

$= \frac{1.5}{25} \times 10^6 = \frac{.3}{5} \times 10^6$

$= \frac{30}{5} \times 10^4 = 6 \times 10^4$ m/s

2

calculat

1 $V_* M_* = V_p M_p$

equation

$V_* = V_p \frac{M_p}{M_*} = 6 \times 10^4 \; \frac{3 \times 10^{-6} M_\odot}{10^{-1} M_\odot}$

$= 6 \times 10^4 \times 3 \times 10^{-5} = 20 \times 10^{-1} = 2$ m/s

2 Calculat

tick marks are approximately 1 m/s

(a bit of rounding error must have crept in)

1 putting it correctly on the graph

(including -ve #s)

negative