Question 1 – Exoplanet Characterization

a) The inclination of GJ 8999 b is approximately 90˚. This is because the planet is observed to transit its host star. Transit events occur only when the orbital plane is almost edge-on from our point of view, corresponding to an inclination near 90˚.

b) In the first figure, there is a thick horizontal band around y =1.000 which shows the normal brightness of the star. The vertical dips going down from this band represent the transits, where the planet passes in front of the star and the brightness drops.

In the second figure, which is zoomed into a single transit, there is a U-shaped dip that shows just one transit over about 200 units of time.

The period of the exoplanet is the time it takes for the planet to complete one orbit and produce another transit.
At the first figure, the first transit happens at about 2.5 days, the next one at 7.5 days, and the next at 12.5 days. The difference between them is about 5 days.

So, the period of this exoplanet is approximately 5 days. This is calculated by measuring the spacing between consecutive transits in the light curve.

c) In the transit graph, the normal brightness of the star is about y = 1.0000.
During the transit, the brightness drops to about 0.9975.
This drop = transit depth = 1.0 – 0.9975 = 0.0025

The Radius of the star GJ 8999 is 0.2 RO.

√transit_depth =√0.0025 = 0.05

This means the planet's radius is 5% of the star's radius.

02 x 0.05 =.01 RO

Planet sizes are usually given in Earth radii.

Planet radius = 0.01x 109 ≈1.1 Earth radii

(109 is a constant : 109 = Sun's radius/ Earth's radius = 696,000 km/ 6,371 km. So the Sun's radius is about 109 times bigger than Earth's)

d) The radial velocity curve is formed because the star moves back and forth due to the planet's mass. The distance between the peak and zero = semi-amplitude K.
For a full wave, peak -dip =2K. So we get K by (highest speed – lowest speed) / 2.
In the graph, the y axis (radial velocity in m/s) goes from -3 to +3.
The first peak (tha star moving towards us the fastest) is about +2.3 m/s. The first dip (moving away the fastest) is about -2.3 m/s.

+2.3 – (-2.3)) = 4.6 m/s =2K
So K ≈ 2.3 m/s

e) $K = M_p \times \sin(i) \times ((2\pi G)/(P \times M_*^2))^{1/3}$

$M_p = K/(\sin(i) \times ((2\pi G)/(P \times M_*^2))^{1/3})$

$K = 2.3$ m/s

$P = 5$ days $\approx 432{,}000$ s

$M_* = 0.2$ MO

$M_* = 0.2 \times 1.989 \times 10^{30}$

If there is a transit, then the inclination angle $i = 90°$ and $\sin(i) = 1$

G, 2π -→ constants

G = gravitational constant

Planet's mass = $M_p = 2.3 \times 1 \times ((2\pi G)/((432{,}000 \times 0.2 \times 1 \times 989 \times 10^{30})^2))^{1/3}$

f) The curve that the planet lies on (or is closest to) tells us about what it's made of. For example, a planet with a bigger radius at the same mass usually has more ice org as. A planet with a smaller radius at the same mass usually has more iron. For GJ 8999 b, mass = 2.1

Earth masses and radius = 1.1 earth radii.

1 Sun's mass ≈ 333,000 earth masses, so 2.1/333,000 ≈10^{-6} solar masses. This means the planet is closesr to the rock planet curve

The mass and radius of GJ 8999 b place it near the curve for 100% rock or 67% rock, 33% ice This suggests that the planet is mostly Rocky possibly with some ice, but not a large amount of iron or gas. The planet is too dense to be mostly ice but not dense enough to be iron-rich. The planet has ≈ 2 Earth masses and ≈ 1.1 Earth radii. This places it closest to the Rocky planet composition on the mass-radius diagram.