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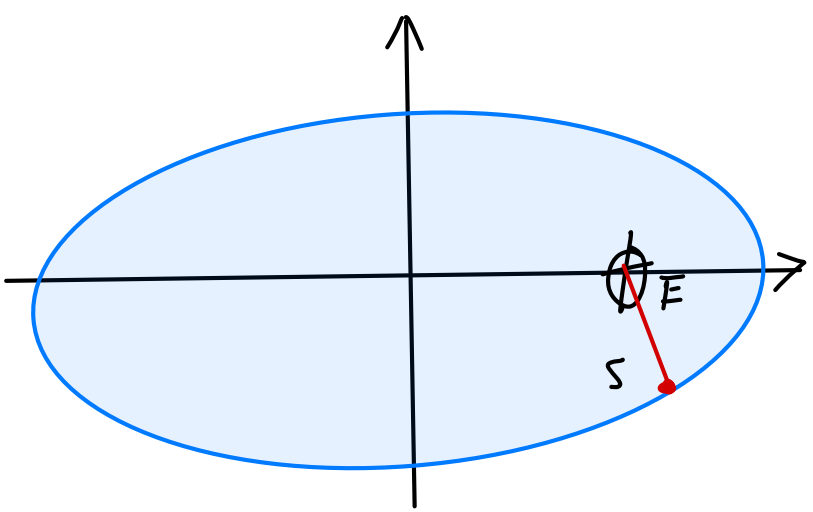
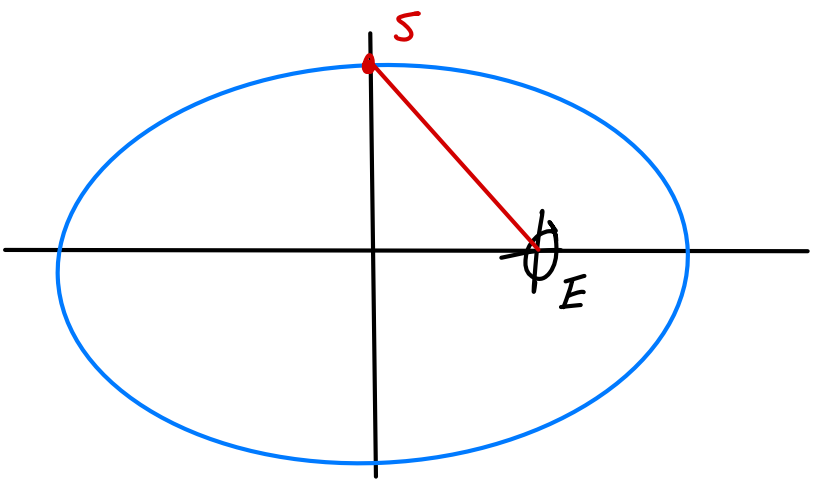
Orbital Mechanics Introductory Problems
Summer 2025

Problem 1: Below there is an incomplete orbital diagram of a 2-body-problem analytical solution. Complete the diagram by labeling true anomaly, radial and tangential unit vectors, semi-latus rectum, semi-major axis, semi-minor axis, periapsis point, apoapsis point, attracting and vacant foci, and velocity vector.



Problem 2: A spacecraft is in a keplerian circular orbit, observations estimate an altitude of 560 km, what are the semi-major axis, radius, and semi-latus rectum of the orbit? Are they different? Why or why not? Using the definition of specific orbital energy, compute the velocity of the spacecraft.

Problem 3: A spacecraft is on an elliptical orbit around the earth and is currently located at the **end of the minor axis** (see diagram below). The orbit has a semi-major axis (a) of 12 earth radii and a semi-minor axis (b) of 10 earth radii, and the radius of the orbit at the time of measurement is 8 earth radii. What is the eccentricity of the orbit? What is the true anomaly at the time of measurement?



Problem 4: A spacecraft in an elliptical orbit of eccentricity 0.5 has a radius of 6 earth radii at a given time (state 1) and a velocity of 5 km/s. At a later time (state 2) the spacecraft estimates a velocity of 4 km/s. What is the radius of the orbit at state 2? What is the specific orbital energy of the orbit? Explain why specific orbital energy remains constant throughout the orbit.

Problem 5: A spacecraft is descending towards the earth on a keplerian orbit of eccentricity 1.2, at the time of measurement the true anomaly is -6 degrees (negative means measured clockwise) measured from the eccentricity vector. The orbit has a specific orbital energy of +6.64 km^2/s^2. What is the semi-major axis of the orbit? What is the radius of the orbit at the time of measurement? What is the periapsis radius of the orbit? Will the spacecraft hit the earth? Why? If it didn't, what is the maximum radius the spacecraft could achieve in this orbit? Make a diagram of this orbit.