1. A spacecraft in Earth orbit has a periapsis altitude of 600 km, and an apoapsis altitude of 800 km. The orbit is inclined at 28.5 degrees to the equator.

- **What is the orbit eccentricity?**
- **What is the orbit semi-major axis?**
- **What is the spacecraft velocity at periapsis?**
- **What is the apsidal rotation rate?**
- **What is the nodal regression rate?**
- **Where is the spacecraft true anomaly 10 minutes after passing periapsis?**
- **What velocity change is required to circularize the orbit to 700 km?**
- **In the preceding question where is the velocity change applied?**

- Eccentricity: 0.014128
- Semi-major axis: 7078.0 km
- Vp: 7.61 km/s
- Apsidal rotation rate: 9.91 deg/day
- Nodal regression rate: -6.85 deg/day
- True anomaly at 10 minutes: 37.42 deg
- Circularization dV: 0.106 km/s, 90.40 deg from the direction of motion toward the orbit interior.
- Circularization occurs at true anom: 90.81 deg

2. A spacecraft is in equatorial Earth orbit at 270 km altitude needs to be transferred to a geostationary position. Define the velocity changes required to perform this orbit adjustment using a minimum velocity change.

- dV 1: 2.43 km/s in velocity vector direction
- dV 2: 1.47 km/s in velocity vector direction

3. The Voyager 2 grand tour of the outer planets started with a launch on 20 August 1977 from ETR and ended with the encounter of Neptune on 24 August 1989. Gravity assist maneuvers at Jupiter, Saturn, and Uranus took advantage of the planetary alignment that allows this mission occurs once every 176 years. The mission time from Earth to Neptune was 12 years. What velocity changes would be required for a Hohmann transfer between Earth and Neptune without the gravity-assist maneuvers? What is the time required for the spacecraft transit between Earth and Neptune. Assume circular coplanar orbits.

- dV: 11.67 km/s
- Transfer Time: 30.55 years

4. A 862 kg communications satellite has attained a periapsis altitude of 41,756 km in the equatorial plane with an eccentricity of 0.0061. What is the minimum velocity change to place the satellite in a geosynchronous orbit? The final altitude must be between 35,776 to 35,796 km.

- dV 1: -0.106 km/s (anti-velocity-vector direction)

- dV 2: -0.100 km/s (anti-velocity-vector direction)

5. **A spacecraft is leaving Earth on a departure hyperbola with a hyperbolic excess velocity (Vhe) of 4.256 km/sec. What velocity was required to escape the Earth's gravitational pull?**
6. What is the radius of the sphere of influence at Mars where a spacecraft would transition between the Sun's gravitational pull and the planet's gravitational pull?

- V_esc: 11.18 km/s

6. What is the radius of the sphere of influence at Mars where a spacecraft would transition between the Sun's gravitational pull and the planet's gravitational pull?

- Sphere of Influence: 576189.393044 km (Using Laplace eqn)

7. **Consider an elliptical equatorial Earth orbit with a semimajor axis of 12,500 km and an eccentricity of 0.472. What is the time from periapsis passage to a position with a true anomaly of 205 degrees?**

- Time of periapsis passage @ 205 deg: 9204.00 s

8. A spacecraft is in a circular orbit at an altitude of 400 km at 28.5 degrees inclination. What velocity change is required to put the spacecraft into an equatorial orbit?

- dV applied at node: 3.78 km/s
- If descending at node, dV is toward the North Pole.
- If ascending at node, dV is toward the South Pole.

9. Create a sketch (hand drawn OK) in the heliocentric reference frame showing the position of Mars on it's orbit on November 2, 2017. Locate the perapsis and apoapsis points in relation to the First Line of Aries. Indicate all other orbit properties required to define the planet location on the sketch.