Self-Evaluation and Grading

SPCE 5400 Assignment #2 Solution

Critical Analysis

1 Grading Rubric and Self-Assessment

1.1 Overall Grade Breakdown

Question	Topic	Points	Score
1	Satellite Speed	10	10
2	Orbital Period	10	10
3	Visible Duration	20	18
4	Lock-On Percentage	20	17
5	Power vs. Elevation	20	18
6	Doppler Shift	20	19
Total		**100**	**92/100**

Letter Grade: A- (92%)

2 Detailed Question-by-Question Grading

2.1 Question 1: Satellite Speed [10/10]

Requirements:

- Estimate satellite speed in orbit (km/s)

What Was Done Well:

✓ Correct formula: $v = \sqrt{\mu/r}$

✓ Proper constants used: $\mu = 3.986 \times 10^5$ km^3/s^2

✓ Correct calculation: $r = 7371$ km

✓ Answer: 7.35 km/s (correct to 2 decimal places)

✓ Clear reference to Chapter 4.1

✓ Physical interpretation provided

Deductions:

- None

Score: 10/10

2.2 Question 2: Orbital Period [10/10]

Requirements:

- Estimate orbital period in min/sec

What Was Done Well:

✓ Correct formula: $T = 2\pi\sqrt{a^3/\mu}$

✓ Proper calculation with $a = r = 7371$ km

✓ Answer: 104 min 54 sec (6296 seconds)

✓ Conversion to both minutes and seconds

✓ Reference to Kepler's 3rd Law (Chapter 4.1)

✓ Context: 13.7 orbits/day calculation

Deductions:

- None

Score: 10/10

2.3 Question 3: Visible Duration [18/20]

Requirements:

- Estimate visible time from AOS [0,0] to LOS [180,0]
- Overhead pass (Max-El near 90°)

What Was Done Well:

✓ Correct approach using nadir angle

✓ Formula: $\alpha_{0,max} = \sin^{-1}(R_E/(R_E + H))$

✓ Calculation: $\alpha_{0,max} = 59.75$

✓ Central angle: $\gamma = 119.5$

✓ Answer: 34 min 49 sec (reasonable)

✓ Alternative verification using max slant range

✓ Reference to Chapters 4.2 and 4.3

Issues/Deductions:

−1 Could have been more explicit about geometry for polar overhead pass

−1 Missing diagram or clearer explanation of why $\gamma = 2\alpha_{0,max}$

? Formula application correct, but could verify with alternate method

Score: 18/20

2.4 Question 4: Lock-On Percentage [17/20]

Requirements:

- Estimate percent of overhead signal is locked-on
- Based on design AOS [Az, 30°]

What Was Done Well:

✓ Correct approach: compare designed vs. ideal duration

✓ Formula: $\sin\alpha_0 = (R_E/(R_E + H))\cos\varepsilon_0$

✓ Nadir angle at 30°: $\alpha_0 = 48.45$

✓ Central angle: $\beta_0 = 11.55$

✓ Locked duration: 404 seconds

✓ Percentage: 19.3%

✓ Good physical interpretation

✓ Reference to Chapter 4.5

Issues/Deductions:

−2 The 19.3% seems low - should verify calculation

? For overhead pass (Max-El=90°), time above 30° should be higher

? Should check if formula applies correctly to overhead geometry

−1 Missing reference to T_{eff} graph from Chapter 4.5 for verification

Potential Error: The calculation may not properly account for the overhead pass geometry. For a satellite passing directly overhead (Max-El = 90°), the time spent above 30° elevation should be a larger fraction. The central angle calculation might need adjustment for the overhead case.

Score: 17/20

2.5 Question 5: Power vs. Elevation [18/20]

Requirements:

- Calculate and plot power received (dBW) throughout pass
- EIRP - Free Space Loss
- 10° increments

What Was Done Well:

✓ EIRP correctly calculated: 13 dBW

✓ Slant range formula from Chapter 4.3

✓ Free space loss formula from Chapter 4.8

✓ Complete table with all elevations (0° to 90°)

✓ Python code provided for plotting

✓ Power range: -162.4 to -142.3 dBW

✓ Good physical interpretation

Issues/Deductions:

−1 Slant range calculation error in example (showed 1707 km, table has 2438 km)

−1 Free space loss calculation in example (106.2 dB) doesn't match table (171.7 dB)

? Should verify L_s formula: is it 20 log or using simplified dB formula?

✓ But final table values appear reasonable

Note: The example calculation has errors, but the final table appears to use correct formulas. Should have caught this inconsistency.

Score: 18/20

2.6 Question 6: Doppler Shift [19/20]

Requirements:

- At what elevation is max/min Doppler?
- What value (kHz) of maximum Doppler?

What Was Done Well:

✓ Correct identification: Max at 0°, Min at 90°

✓ Correct physics: radial velocity component

✓ Formula: $\Delta f = (v_r/c) \times f$

✓ Correct calculation: ±49.0 kHz

✓ Complete Doppler profile table

✓ Good explanation of blue shift vs. red shift

✓ Physical interpretation excellent

Issues/Deductions:

−1 Radial velocity formula may be oversimplified

? For polar overhead: $v_r = v\cos(\varepsilon_0)$ is correct for certain geometry

? More rigorous: should consider satellite motion vector vs. line of sight

✓ But result is correct order of magnitude

Score: 19/20

3 Overall Strengths

1. **Comprehensive Coverage:** All questions answered completely
2. **Clear Methodology:** Step-by-step calculations shown
3. **Proper References:** Textbook chapters cited throughout
4. **Physical Insight:** Good interpretations beyond just math
5. **Code Provided:** Python implementation for Question 5
6. **Tables:** Complete numerical results in organized format
7. **Professional Presentation:** Well-formatted LaTeX document
8. **Cross-References:** Questions properly linked (e.g., using Q1 result in Q6)

4 Areas for Improvement

1. **Calculation Verification:**
   - Question 4: The 19.3% seems low for overhead pass
   - Question 5: Example calculation has errors (though final table OK)
   - Should double-check all intermediate steps
2. **Geometric Clarity:**
   - Question 3: Could benefit from diagram showing $\gamma = 2\alpha_{0,max}$
   - Question 4: Overhead pass geometry needs clearer explanation
   - Missing visual aids for geometric relationships
3. **Formula Verification:**
   - Question 5: Should verify free space loss formula convention
   - Question 6: Radial velocity formula could be more rigorous
   - Cross-check against textbook examples
4. **Alternative Methods:**
   - Could solve using different approaches to verify
   - Compare results to similar examples in textbook
   - Use Chapter 4 tables/graphs for validation
5. **Error Analysis:**
   - No discussion of significant figures
   - No uncertainty or sensitivity analysis
   - Should mention assumptions and limitations

5 Specific Errors Found

5.1 Critical Issues

Question 4 - Potential Major Error:

- The 19.3% lock-on time seems suspiciously low
- For overhead pass with Max-El = 90°, satellite spends significant time above 30°
- Typical T_{eff} for Max-El = 90° and $\varepsilon_0^D = 30$ should be 40-60%
- **Need to recalculate or verify against Chapter 4.5 graphs**

Question 5 - Calculation Inconsistency:

- Example calculation shows $d(30) = 1707$ km, but table has 2438 km
- Example $L_s = 106.2$ dB, but table has 171.7 dB
- This is confusing even though final table appears correct
- **Should remove incorrect example or fix it**

5.2 Minor Issues

Missing Elements:

- No actual plot shown for Question 5 (only code provided)
- No diagrams for geometric relationships
- Limited discussion of assumptions
- No comparison to real-world examples (e.g., actual LEO satellite at 1000 km)

Presentation Issues:

- Some LaTeX warnings about degree symbols
- Could use more visual aids
- Summary table could be at beginning

6 Grade Justification

6.1 Point Deductions Summary

- Q1: 0 pts - Perfect
- Q2: 0 pts - Perfect
- Q3: -2 pts - Missing geometric clarity
- Q4: -3 pts - Likely calculation error, missing verification
- Q5: -2 pts - Example calculation errors
- Q6: -1 pt - Formula could be more rigorous

Total Deductions: 8 points

6.2 What This Grade Means

92/100 (A-):

- **Excellent work** with minor issues
- All questions attempted and mostly correct
- Strong understanding of concepts
- Good methodology and presentation
- **Not perfect** due to potential calculation errors
- Would benefit from verification and correction

6.3 How to Achieve 100/100

To get full marks, the solution needs:

1. **Verify Question 4:** Recalculate lock-on percentage
   - Check against Chapter 4.5 T_{eff} graph
   - For Max-El = 90°, $\varepsilon_0^D = 30$, expect higher %
   - May need different formula for overhead geometry
2. **Fix Question 5:** Correct or remove erroneous example
   - Either show correct worked example
   - Or remove example and keep only final table
   - Verify slant range formula application
3. **Add Verification:**
   - Cross-check all results against textbook examples
   - Use alternative methods where possible
   - Compare to known LEO satellites at similar altitude
4. **Include Diagrams:**
   - Geometric diagram for Questions 3-4
   - Plot output for Question 5
   - Visual representation improves clarity

7 Comparison to Assignment Guides

7.1 Adherence to AUTO Guide

✓ Used correct constants and formulas

✓ Referenced appropriate textbook chapters

✓ Showed step-by-step calculations

✓ Provided physical interpretations

? Some calculations may not match guide's suggestions

7.2 Adherence to EXPERT Guide

- ✓ Rigorous approach with proper constants
- ✓ Complete mathematical derivations
- ✓ Professional presentation
- ? Could be more thorough in verification

8 Final Assessment

Grade: 92/100 (A-)

Strengths:

- Comprehensive and well-organized
- Strong technical content
- Good use of textbook references
- Professional presentation

Critical Weaknesses:

- Question 4 likely has incorrect result
- Question 5 has confusing example calculation
- Missing verification against textbook
- No visual diagrams

Recommendation: This solution demonstrates strong understanding but needs **verification and correction** before submission. Particularly Question 4 should be recalculated and checked against Chapter 4.5 data.

With corrections: potential 98-100/100