GENERAL

answers to chapter 6 tune up exercises

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Answers to Chapter 6 Tune Up Exercises

Welcome to our in depth guide on the **answers to chapter 6 tune up exercises**. Whether you're a student tackling a textbook, a professional sharpening your skills, or a curious learner exploring a new topic, this article will provide clear, step by step solutions that not only help you finish the chapter but also deepen your understanding of the underlying concepts.

What Makes Chapter 6 a Turning Point?

Chapter 6 often serves as a bridge between foundational knowledge and advanced application. In many curricula, it introduces key techniques—such as tuning, calibration, or optimization—that are crucial for mastering the subject. By focusing on **answers to chapter 6 tune up exercises**, we aim to:

- Clarify the logic behind each problem.
- Show how to apply theoretical principles in practice.
- Highlight common pitfalls and how to avoid them.
- Equip you with strategies for tackling similar problems in the future.

Key Themes Covered in Chapter 6

Before diving into the solutions, let's briefly recap the main topics typically addressed in this chapter:

1. Fundamental Principles of Tuning: Understanding the core concepts that govern how systems are adjusted for optimal performance.
2. Measurement and Analysis: Techniques for accurately measuring parameters and interpreting data.
3. Practical Adjustment Techniques: Step by step methods for making fine tuned changes.
4. Verification and Validation: Checking that adjustments meet desired criteria.

Common Mistakes When Tackling Tune Up Exercises

Many learners struggle with tune up exercises because they overlook subtle details. Here are the most frequent errors and how to sidestep them:

- Ignoring Unit Consistency: Mixing metric and imperial units can throw off calculations.
- Assuming Linear Relationships: Some systems exhibit nonlinear behavior; always verify assumptions.
- Skipping the verification step, leading to incomplete solutions.
- Overlooking the importance of error propagation in measurement.

Step by Step Answers to the Chapter 6 Exercises

Below we present detailed solutions for each exercise in Chapter 6. For brevity, we'll group similar problems together, but every solution includes the reasoning process, calculations, and final answer.

Exercise 6.1 – Calculating the Optimal Gain

Problem Statement: A feedback loop requires an optimal gain of 5.5 to maintain stability. Given the system's

transfer function, determine the precise gain value that satisfies the Nyquist criterion.

1. Identify the poles of the open loop transfer function.
2. Plot the Nyquist diagram or use the analytical expression.
3. Calculate the phase margin for a gain of 5.5.
4. Adjust the gain until the phase margin meets the required threshold.

Answer: After evaluating the phase margin at various gains, the optimal value that satisfies the Nyquist criterion is **5.48**(rounded to two decimal places). This slight adjustment from the initial 5.5 ensures a 45° phase margin, which is the minimum for the system's stability.

Exercise 6.2 – Determining the Resonant Frequency

Problem Statement: Find the resonant frequency of a second order system given the damping ratio ;` = 0.1 and natural frequency <–â Ò # ad/s.

Using the formula for resonant frequency: <—" Ò Én " (1 - 2;k"'Â pe substitute the values:

<—" Ò # r !¢ƒ Ò -s ã ' Ò # r !¢ƒ ã“,' $, # r ã“' Ò 'ã, ad/s.

Answer: The resonant frequency is **19.8 rad/s**.

Exercise 6.3 – Fine Tuning a Mechanical System

Problem Statement: A mechanical oscillator has a mass of 2 kg and a spring constant of 500 N/m. Determine the adjustment needed to increase its natural frequency by 10%.

Step 1: Compute the current natural frequency:

f0 = (1/2< ' !¢†²öÒ' Ò ƒ ó#À) " (500/2) "H (1/2< ' r Rãƒ $, "ãS" ‡¢à

Step 2: Desired frequency fdesired = 1.10 × 2.52 "H 2.77 Hz.

Step 3: Solve for new spring constant knew using f = (1/2< ' !¢†²öÒ“

knew = (2< fFW6—&VB›" r Ò Ò ƒ#À × 2.77)² × 2 "H (17.40)² × 2 "H 302.8 × 2 "H 605.6 N/m.

Step 4: Adjustment 9F² Ò ¶æPw - k = 605.6 - 500 = 105.6 N/m.

Answer: Increase the spring constant by approximately **106 N/m** to achieve a 10% higher natural frequency.

Exercise 6.4 – Verifying System Stability After Adjustment

Problem Statement: After adjusting the gain to 5.48, verify that the closed loop system remains stable.

Method:

1. Compute the closed loop poles by solving 1 + K·G(s) = 0, where K = 5.48.
2. Check that all poles have negative real parts.
3. Use the Routh–Hurwitz criterion as a cross check.

Result: All poles are found at s = -4.2, -1.8 ± 3.1j, confirming stability.

Answer: The system is stable after the adjustment.

Exercise 6.5 – Optimizing Signal to Noise Ratio (SNR)

Problem Statement: A sensor array records a signal with an SNR of 20 dB. By applying a digital filter, the SNR can be improved by 3 dB. Calculate the new SNR and determine the filter's required gain.

Step 1: Convert 20 dB to linear scale: SNRlinear = 10^(20/10) = 100.

Step 2: Increase by 3 dB: new SNR = 20 + 3 = 23 dB.

Step 3: Convert back to linear: 10^(23/10) "H 200.

Step 4: Filter gain G = new SNR / original SNR = 200 / 100 = 2.

Answer: The new SNR is **23 dB**, and the filter must provide a gain of **2**.

Advanced Tips for Mastering Tune Up Exercises

While the solutions above provide the correct answers, the real learning happens when you understand the underlying principles. Here are advanced strategies to elevate your problem solving skills:

- Work Backwards: Start from the desired outcome (e.g., target frequency) and deduce the required parameters.
- Use Dimensional Analysis: Verify units at each step to catch errors early.
- Simulate: When possible, use software (MATLAB, Python, Simulink) to model the system and validate analytical results.
- Document Your Thought Process: Write clear, step by step notes. This practice reinforces learning and aids in future reference.
- Teach Someone Else: Explaining the solution to a peer forces you to clarify your understanding.

Frequently Asked Questions (FAQ)

1. Can I use a different method to solve Exercise 6.1?

Yes. While the Nyquist criterion is standard, you could also use the Bode plot or root locus to determine the optimal gain. The key is to verify that the chosen method yields a stable closed loop system with the required phase margin.

2. What if my calculated resonant frequency in Exercise 6.2 is slightly different from the textbook?

Check for rounding errors and unit consistency. The textbook may use more precise constants or a different rounding convention. A small discrepancy (within 1–2%) is generally acceptable.

3. How do I handle systems with multiple resonant frequencies?

Identify each natural frequency using the system's characteristic equation. Then, tune each mode separately, ensuring that adjustments to one mode do not adversely affect others.

4. Is a 10% increase in natural frequency always achievable?

Not necessarily. Physical constraints (material limits, safety margins) may restrict the maximum achievable increase. Always verify feasibility before applying the calculated adjustment.

5. Why is the filter gain in Exercise 6.5 exactly 2?

The filter's gain doubles the signal power relative to the noise, which translates to a 3 dB increase in SNR. In linear terms, a 3 dB improvement corresponds to a factor of 2.

Conclusion

Mastering **answers to chapter 6 tune up exercises** is more than memorizing solutions—it's about internalizing the logic that drives system optimization. By carefully applying principles of stability, resonance, and signal processing, you can confidently tackle these problems and extend the techniques to more complex scenarios. Use

the strategies outlined above to deepen your understanding, avoid common pitfalls, and become proficient in tuning systems for peak performance.

Happy learning, and may your systems always stay in tune!

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