

**Part I – Newton’s 3rd Law & Thrust**

1. Explain how a rocket can accelerate in space where there is no air.

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2. According to Newton’s 3rd Law, what is the “action” and what is the “reaction” in rocket propulsion?

Action:

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Reaction:

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3. If the exhaust velocity increases, what happens to thrust? Explain conceptually.

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4. If rocket mass doubles but thrust stays the same, what happens to acceleration?  
Use  $a = F / m$  in your explanation.

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**Part II – Forces at Launch**

5. If thrust equals weight, what is the rocket’s acceleration? Explain using Newton’s 2nd Law.

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6. If thrust is greater than weight, what happens to the rocket’s motion?

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7. If a rocket’s mass doubles but thrust stays the same, what happens to acceleration? Use  $a = F/m$ .

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**Part III – Building Orbit**

8. Why must rockets turn sideways instead of continuing straight up?

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9. Why is horizontal velocity necessary for orbit?

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10. If a rocket goes straight up and stops its engines, what will eventually happen?

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**Part IV – Orbital vs Escape Velocity**

Orbital velocity  $\approx 7.8$  km/s

Escape velocity  $\approx 11.2$  km/s

11. Why is escape velocity larger than orbital velocity?

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12. Does escape velocity depend on the mass of the rocket? Explain.

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13. If a rocket reaches orbital velocity but not escape velocity, what will happen?

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**Part V – Staging & Efficiency**

14. Why does dropping empty fuel tanks improve rocket performance?

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15. If thrust stays constant but mass decreases during flight, what happens to acceleration?

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16. Explain why most of a rocket's mass at launch is fuel.

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**Part VI – Critical Thinking (Honors)**

17. Why can airplanes not reach orbit, even if they fly very high?

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18. Why is atmospheric drag strongest near the beginning of launch?

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**Part III – Reentry Physics**

8. Objects in orbit move about 7.8 km/s.  
Why does returning to Earth require removing a large amount of energy?

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9. What primarily causes heating during reentry?

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10. Typical reentry temperatures can exceed 1,500°C and may reach 2,700°C.  
Why would an unprotected aluminum spacecraft fail under these conditions?

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**Part IV – Reentry Angle**

11. What happens if a spacecraft enters the atmosphere too steeply?

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12. What happens if a spacecraft enters too shallowly?

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13. Why is reentry angle considered a narrow safety window?

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**Part V – Heat Shield Designs**

14. How does an ablative heat shield protect a spacecraft?

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15. Why did the Space Shuttle NOT use an ablative heat shield?

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16. Give one advantage and one disadvantage of each system:

Capsule (Ablative):

Advantage: \_\_\_\_\_

Disadvantage: \_\_\_\_\_

Shuttle (Reusable Tiles):

Advantage: \_\_\_\_\_

Disadvantage: \_\_\_\_\_