At which position would the spacecraft feel the strongest net (total) force?

- a. position A
- b. position B
- c. position C
Test 2 review questions

An important line in the absorption spectrum of stars occurs at a wavelength of 656 nm for stars at rest. Imagine that you observe five stars (A-E) from Earth and discover that, for each star, this absorption line is at the wavelength shown in the table below. Which of the stars is moving with the greatest velocity away from Earth?

<table>
<thead>
<tr>
<th>STAR</th>
<th>Wavelength of Absorption Line</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>649 nm</td>
</tr>
<tr>
<td>B</td>
<td>660 nm</td>
</tr>
<tr>
<td>C</td>
<td>656 nm</td>
</tr>
<tr>
<td>D</td>
<td>658 nm</td>
</tr>
<tr>
<td>E</td>
<td>647 nm</td>
</tr>
</tbody>
</table>

a. Star A  
b. Star B  
c. Star C  
d. Star D  
e. Star E
Test 2 review questions

What kind of information would you need to determine the temperature of a star?

a. a photographic image of the star
b. the wavelengths of star’s absorption lines
c. the star’s spectral curve
d. both a & b
e. all of the above
Chapter 8
Formation of the Solar System II
8.4 The Aftermath of Planet Formation

Our goals for learning:

- Where did asteroids and comets come from?
- How do we explain “exceptions to the rules”?
- How do we explain the existence of our Moon?
- Was our solar system destined to be?
Where did asteroids and comets come from?
Asteroids and Comets

• Many planetesimals remained scattered between the newly formed planets.
• Leftovers from the accretion process
• **Rocky asteroids** inside frost line
• **Icy comets** outside frost line
Asteroids & Comets

- **Asteroids** are the rocky leftover planetesimals of the inner solar system.
- The total mass of the asteroids in the asteroid belt is only a tiny fraction of the mass of any terrestrial planet.
- **Comets** are the ice-rich leftover planetesimals of the outer solar system.

(More details in Ch.12)
How do we explain “exceptions to the rules”?

- Uranus’s rotation axis
- Earth’s large moon
- Venus’s rotation direction

Today we think that most of these exceptions arose from collisions or close encounters with leftover planetesimals.

4. Several notable exceptions to these general trends stand out, such as planets with unusual axis tilts or surprisingly large moons, and moons with unusual orbits.
Heavy Bombardment Period

- Leftover planetesimals bombarded other objects in the late stages of solar system formation.
- Vast majority of these collisions occurred in the first few hundred million years of our solar system’s history, which we call the heavy bombardment period.
Origin of Earth’s Water

- If the planetesimals that bombarded Earth were made of rock & metal, where did the water on Earth come from?
- Water may have come to Earth by way of icy planetesimals.
Captured Moons

Two moons of Mars: Phobos (left) and Deimos (right)

- Unusual moons of some planets may be captured planetesimals.
How do we explain the existence of our Moon?

Our Moon is too large to be explained by the planetesimal capture scenario.
A Mars-sized planetesimal crashes into the young Earth, shattering both the planetesimal and the Earth’s crust.

Stripped matter began to orbit…

…then accreted to form Moon.
Moon Formation Movies
Odd Rotation

- Giant impacts might also explain the different rotation axes of some planets.

4. Several notable exceptions to these general trends stand out, such as planets with unusual axis tilts or surprisingly large moons, and moons with unusual orbits.
How would the solar system be different if the solar nebula had cooled, with a temperature half its actual value?

a) Jovian planets would have formed closer to Sun  
b) There would be no asteroids  
c) There would be no comets  
d) Terrestrial planets would be larger
Lecture-Tutorial (LT):
Temperature and Formation of Our Solar System (pp. 103-104)

• Work with a partner!
• Read the instructions and questions carefully.
• Discuss the concepts and your answers with one another.
• Come to a consensus answer you both agree on.
• If you get stuck or are not sure of your answer, ask another group.
• If you get really stuck or don’t understand what the LT is asking, ask one of us for help.
Was our solar system destined to be?

- Formation of planets in the solar nebula seems inevitable.
- But details of individual planets could have been different depending on the details of the physical condition.
Quiz

Which of these facts is NOT explained by the nebular theory?

a) There are two main types of planets: terrestrial and jovian.
b) Planets orbit in same direction and plane.
c) Existence of asteroids and comets.
d) Number of planets of each type (4 terrestrial and 4 jovian).
# What have we learned?

- **Where did asteroids and comets come from?**
  - They are leftover planetesimals, according to the nebular theory

- **How do we explain “exceptions to the rules”?**
  - Bombardment of newly formed planets by planetesimals may explain the exceptions

- **How do we explain the existence of Earth’s moon?**
  - Material torn from Earth’s crust by a giant impact formed the Moon

- **Was our solar system destined to be?**
  - Formation of planets seems inevitable.
  - Detailed characteristics could have been different.
8.5 The Age of the Solar System

Our goals for learning:

- How does radioactivity reveal an object’s age?
- When did the planets form?
How do we measure the age?
Radioactive Decay

- Some isotopes decay into other nuclei
- A half-life is the time for half the nuclei in a substance to decay

So if we measure the ratio of elements (parent & daughter isotopes), then we can tell the age of the rock. This is called radiometric dating.
Suppose you find a rock originally made of potassium-40, half of which decays into argon-40 every 1.25 billion years. You open the rock and find 15 atoms of argon-40 for every atom of potassium-40. How long ago did the rock form?

a) 1.25 billion years ago
b) 2.5 billion years ago
c) 3.75 billion years ago
d) 5 billion years ago
When did the planets form?

- Radiometric dating tells us that oldest moon rocks are 4.4 billion years old.
- Oldest meteorites are 4.55 billion years old.
- Planets probably formed 4.5 billion years ago.
What have we learned?

• How does radioactivity reveal an object’s age?
  – Some isotopes decay with a well-known half-life
  – Comparing the proportions of those isotopes with their decay products tells us age of object

• When did the planets form?
  – Radiometric dating indicates that planets formed 4.5 billion years ago