SEASONS
Session 1: Space-Based Perspectives

1. Draw a space-based diagram that shows why we experience day and night on Earth.

Make sure that you:
- Include all objects that you think are important to show your reasoning.
- Label the key parts of your diagram.
- Shade your diagram to show the unlit (nighttime) part.
- Draw a triangle on a location (a city) that is currently experiencing daytime.
- Draw an X on a location (a city) that is currently experiencing nighttime.
- Think about how a city like Boston experiences a day-night cycle. Add arrows to your diagram to show the movement of the Earth that explains why Boston experiences a day-night cycle. Think carefully about which direction things should move.
SEASONS
Session 2 - 3: Apparent Path of the Sun in the Sky

A. Make a prediction:
I think the Sun’s apparent path in the sky each day is **different** throughout the year.

< the same / different >

If you think it is the same, explain why it is the same.
If you think it is different, describe how it is different.

*It is different each day because Earth’s fixed tilt of Earth changes the*

*Earth-based orientation with the Sun as Earth moves around the orbital*

*plane.*

*(But students won’t be expected to know that yet, this is just to collect their*

*initial ideas.)*
B. Collect data for Boston:

<table>
<thead>
<tr>
<th>Season and date</th>
<th>Marker Color (on SunTracker)</th>
<th>Sun Angle at Midday (in degrees)</th>
<th>Length of Day (in hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Winter (December 21)</td>
<td>blue</td>
<td>24°</td>
<td>9 hours</td>
</tr>
<tr>
<td>Spring (March 21)</td>
<td>green</td>
<td>48°</td>
<td>12 hours</td>
</tr>
<tr>
<td>Summer (June 21)</td>
<td>red</td>
<td>71°</td>
<td>15 hours</td>
</tr>
<tr>
<td>Fall (September 21)</td>
<td>black</td>
<td>48°</td>
<td>12 hours</td>
</tr>
</tbody>
</table>

C. Compare and analyze data for Boston:

1. Which season has the highest Sun angle at midday? _________________________________ Summer
2. Which season has the lowest Sun angle at midday? _________________________________ Winter
3. Which season has the longest day length? _________________________________ Summer
4. Which season has the shortest day length? _________________________________ Winter
5. Which seasons have the same Sun angle at midday / day length? _____________________ Spring and Fall
6. Was the Sun ever directly overhead in Boston? _________________________________ Nope

D. Record your ideas:

How do you think the Sun’s height in the sky and the length of day affect temperature on Earth?

1. Here are some ways I think the Sun’s **height in the sky** affects temperature:
   
   Higher sun angles produce more concentrated light, resulting in more energy and higher temperature. (But students aren’t expected to know that yet.)

2. Here are some ways I think the **length of day** affects temperature:
   
   More hours of daylight mean light and energy transmit to a location on Earth for a longer time, raising the temperature. (Again, hasn’t been explained yet.)
SEASONS
Session 4: Sun Angle and Energy

Activity: Modeling Light from the Sun

In this activity you will use the littleBits light sensors to model sunlight hitting the ground at different angles. You will explore how Sun angle affects the amount of energy we receive from the Sun (and therefore, temperature).

A. Collect data:

Complete this table with your group:

<table>
<thead>
<tr>
<th>Sun Angle (in degrees)</th>
<th>Intensity of Light (number you see on the littleBits sensor)</th>
</tr>
</thead>
<tbody>
<tr>
<td>90°</td>
<td>different for each group</td>
</tr>
<tr>
<td>60°</td>
<td>different for each group</td>
</tr>
<tr>
<td>30°</td>
<td>different for each group</td>
</tr>
<tr>
<td>10°</td>
<td>different for each group</td>
</tr>
</tbody>
</table>

B. Compare and analyze:

At which Sun angle is the light most intense? 90°

When sunlight is more intense, the temperature will be (warmer / colder). warmer

At which Sun angle is the light least intense? 10°

When sunlight is less intense, the temperature will be (warmer / colder). colder

C. Record your ideas:

Based on what we have learned so far, explain why you think it is warmer in the summer than in the winter.

Try to connect what you have learned about

1. how the Sun appears to move in the sky during different seasons;
2. how the Earth’s axis affects the mid-day Sun angle; and
3. how the Sun’s angle in the sky affects the intensity of light we receive.

It is warmer in the summer because the hemisphere is tipped towards the Sun, which results in a higher sun angle. Higher sun angles produce more intense sunlight, and therefore more concentrated energy (and warmth).
SEASONS
Session 5: Earth’s Tilted Axis

1. **Model a Year**

Model Earth orbiting the Sun, using the Seasons sheet on your table as a guide.

*Note: Be sure to always point your Earth’s axis in the direction indicated by the instructor.*

- Place your team’s Seasons Sheet on the table. Match the orientation of the seasons on the sheet to the signs hung around the room. Place a ring on the Seasons sheet. Place your Sun on the ring.
- Each team member should stand around your table at one of the season positions marked on the sheet. Each team member should represent a different season.
  - **Summer team member:**
    - Hold Earth on the side of the Sun that represents Summer. Orient the tilt of Earth’s axis in the direction indicated by the instructor.
    - Holding the dowel that represents Earth’s axis, move Earth through your season to model how Earth orbits around the Sun during Summer.
    - Pass Earth to the Fall team member, always keeping the axis pointed in the correct direction.
  - **Fall, Winter, and Spring team members:**
    - Take turns repeating the steps above during your season. Fall team member will model Earth’s orbit during Fall, then pass Earth to Winter team member, and so on.
    - Make to complete a full Year by passing Earth through every season and back to Summer.

2. **Model a Day at Different Times of Year**

- **Summer team member:** Rotate Earth at the Summer position, so your Lego person experiences both night and day. All teammates should make sure that the axis orientation remains correct.
- **Fall team member:** Rotate Earth at the Fall position, so your Lego person experiences both night and day. All teammates should make sure that the axis orientation remains correct.
- Pass and repeat for the other two seasons.

3. **Observe from the Model**

When Earth experiences **Summer** in the Northern Hemisphere:

1. The Northern Axis is tilted **towards** the Sun.
2. The Southern Axis is tilted **away from** the Sun.
3. To see the Sun at midday, Lego person must look **up**, **high** in the sky.

When Earth experiences **Winter** in the Northern Hemisphere:

1. The Northern Axis is tilted **away from** the Sun.
2. The Southern Axis is tilted **towards** the Sun.
3. To see the Sun at midday, Lego person must look **ahead**, **low** in the sky.
A. Interpret This Diagram:

1. The Northern Hemisphere is tilted _______ away from _______ the Sun.
2. Sketch in five light rays from the Sun, to show how you think sunlight reaches Earth.
3. Shade the diagram to show which part of Earth is dark.
4. What time of day do you think it is for the stick person above? _______ midday _______
   < sunrise / midday / sunset / midnight >
5. Circle which of the three figures below you think best represents the angle of sunlight hitting the
   person’s ground at the moment shown above. The angle of sunlight is the same as the Sun Angle.
6. What season do you think it is for the stick person? _______ winter _______
   < summer / winter >
B. Interpret this diagram:

Diagram NOT to scale.

1. The Northern Hemisphere is tilted towards the Sun.
2. Sketch in five light rays from the Sun, to show how you think sunlight reaches Earth.
3. Shade the diagram to show which part of Earth is dark.
4. What time of day do you think it is for the stick person above? midday
5. Circle the figure that you think best represents the angle of sunlight hitting the person's ground (and therefore, the Sun in the person's sky) at the moment shown above.
6. What season do you think it is for the person? summer

C. Compare:

When the Northern Hemisphere is tilted towards the Sun, the Sun is high in the sky at midday. This is summer.

When the Northern Hemisphere is tilted away from the Sun, the Sun is low in the sky at midday. This is winter.
SEASONS
Session 6: Bonus Questions

1. Sketch in five light rays from the Sun.

2. Shade the dark part of Earth.

3. What time of day is it for Person A? midnight

4. What season is it for Person A? summer
   Explain why you think so:
   It is summer for Person A because they are standing in the Northern Hemisphere, and this Hemisphere is currently tilted toward the Sun.

5. What time of day is it for Person B? mida

6. What season is it for Person B? winter
   Explain why you think so:
   It is winter for Person B because they are standing in the Southern Hemisphere, and this Hemisphere is currently tilted away from the Sun.
1. Sketch in **five light rays** from the Sun.

2. Shade the **dark part** of Earth.

3. **True or False?** Figure 1 and Figure 2 show the same time of day and the same season for Person A.  _______________

4. Sketch in a person for whom the Sun is **directly overhead** on this day. Label this Person B.

5. Sketch in a person who will **never see the Sun** on this day. Label this Person C.

6. Sketch in a person who will **never experience darkness** on this day. Label this Person D.
SEASONS
Session 7: Tilt and Day Length

I. Collect Data: Total hours of daylight around the world

A. The Northern Hemisphere is tilted __________ toward __________ the Sun.
   < toward / away from >

B. A place that spends this entire day in darkness (never sees the Sun) is __________.
   This place is in the _______ Hemisphere, close to the _______ Pole _______.
   < Northern / Southern >                        < North Pole / South Pole / Equator >

C. A place that spends less time in daylight than darkness is __________.
   This place is in the _______ Hemisphere, which is tilted __________ away from __________.
   < Northern / Southern >                       < toward / away from >

D. The Northern Hemisphere is tilted __________ away from __________ the Sun.
   < toward / away from >

E. A place that spends more time in daylight than darkness is __________.
   This place is in the _______ Hemisphere, which is tilted __________ toward __________ the Sun.
   < Northern / Southern >                       < toward / away from >

F. A place that spends the same amount of time in daylight as darkness is __________.
   This place is located near the __________.
   < North Pole / South Pole / Equator >

G. A place that spends the entire day in daylight (never sees the Sun set) is __________.

H. Barrow, Alaska spends __________ the same amount ________ time in daylight than darkness.
   < more / the same amount of / less >

I. Puerto Montt, Chile spends __________ the same amount ________ time in daylight than darkness.
   < more / the same amount of / less >
2. **Compare**

A. When the Northern Hemisphere is tilted toward the Sun, the Southern Hemisphere is tilted ______ away from ______ the Sun.

B. Cities in the hemisphere tilted toward the Sun have ______ more ______ hours of daylight than darkness.

C. Cities in the hemisphere tilted away from the Sun have ______ fewer ______ hours of daylight than darkness.

D. Some places on Earth have roughly equal amounts of daylight and darkness every day of the year. These places are close to the ______ Equator ______.

E. There are places on Earth where on certain days of the year, the Sun never rises or never sets for an entire day. These places are close to the ______ Poles ______.

F. On September 21 and March 21, the total hours of daylight are ______ the same as ______ the total hours of darkness everywhere on Earth.

These dates are known as the ______ Equinoxes ______.
SEASONS
Session 8: Earth’s Orbit

1. What shape is Earth’s orbit?
   A. Draw a diagram of Earth’s orbit around the Sun from an overhead perspective.
   B. Label all the key parts of your diagram.
   C. Label where you think Earth is when it’s September, December, March, and June.

2. Distance from Earth to the Sun
   Predict: In what month (if ever) do you think Earth is closest to the Sun? January

<table>
<thead>
<tr>
<th>Date (and season in Boston)</th>
<th>Collect Data distance from Earth to the Sun (in kilometers)</th>
</tr>
</thead>
<tbody>
<tr>
<td>December 21 Boston winter</td>
<td>147 million kilometers</td>
</tr>
<tr>
<td>March 21 Boston spring</td>
<td>149 million kilometers</td>
</tr>
<tr>
<td>June 21 Boston summer</td>
<td>151 million kilometers</td>
</tr>
<tr>
<td>September 21 Boston fall</td>
<td>149 million kilometers</td>
</tr>
</tbody>
</table>
3. Compare and analyze

Use the data in your table on the previous page to answer these questions:

Earth is closest to the Sun when it is ___________ in the Northern Hemisphere.  
< fall / winter / spring / summer >

Earth is farthest from the Sun when it is ___________ in the Northern Hemisphere.  
< fall / winter / spring / summer >

4. Reflect

A common belief for why we experience Seasons is that Earth is closer to the Sun in the summer, and farther away in the winter.

Do you agree or disagree with this?  ___________ disagree  
< agree / disagree >

Explain your reasoning. If you disagree, please explain why you think we have seasons.

Earth is further away from the Sun when it is summer in the Northern Hemisphere, so this doesn’t make sense. We have seasons because the fixed tilt of the Earth results in more intense sunlight and longer days during certain periods of the orbit around the Sun.

5. Recap

i. What season is it for the person in the diagram to the right?  ___________ winter  
< fall / winter / spring / summer >

ii. The person in this diagram will experience (circle one):

a. A longer day and shorter night
b. Roughly an equal day and night

[Circle c. A longer night and shorter day]

iii. Sketch a side-view of Earth and the Sun when the Southern Hemisphere is experiencing winter.