**WHAT IS A BLACK HOLE?**

**Student’s worksheet**

***MATERIALS***

Part 1, 2: Heavy, medium and light marbles.

Part 3: Cardboard and light marble.

Part 4: Heavy and light marbles, aluminum ball and weighing scale.

***FULL ACTIVITY DESCRIPTION***

***Part 1: What is gravity again?***

1. Cover a stretchy sheet over a large round bowl. The surface of the sheet is like a small portion of space in 2 dimensions (remember that space is 3-dimensional and surrounds us everywhere in all directions).

2. Place a medium weighted marble on the sheet. Observe there’s a dip (curvature) due to the mass of the marble.

3. With the medium marble at the center, roll a lighter marble on the sheet (instead of dropping it to fall straight to the medium marble). Do you see that the light marble moves toward the heavier one and rolls around it?

→ Any object has mass can distort space like the marble does to the stretchy sheet, causing objects to be attracted to each other. So this effect is called **gravity, which is the bending of space.**

***Part 2: How does black hole attract and capture other objects?***

1. A black hole can be more massive than a billion Suns, so a heavy marble represents a black hole. Take the medium and light marbles from activity 1 to represent other objects in space e.g. stars, planets.

2. Place the heavy marble at the center of the sheet, and then roll the other 2 marbles on the sheet (instead of dropping them to fall straight to the center). How do the 2 lighter marbles move on the sheet?

3. Remove everything. Then, place the medium marble in the center of the stretchy sheet and roll the lighter marble. It orbits and falls towards the medium marble as a result of gravity from the medium marble. Then, roll in the heavy marble; the medium and light marbles follow the heavy marble and fall into it.

4. Observe the bending of the sheet, order the 3 marbles (heavy, medium, light) in increasing strength of gravity. Explain why you give this order.

5. Based on the observations, what is the effect of the heavy marble on the lighter marbles?

6. Relate questions 4 and 5, why does a black hole cause other objects to fall into it?

***Part 3: How do black holes prevent objects from escaping once they have fallen in?***

1. To escape the pull due to gravity, you need to move fast enough (just like a space rocket shooting away from Earth).
2. Take a cardboard and bend it slightly to make a flat curve. Roll a small marble from one end of the cardboard so that it rolls to the other end and falls out.
3. Why can the marble go up the bend and escape out of the cardboard? *(Relate the curve of the cardboard with how strong gravity is acting on the marble. How does this affect how fast the marble can roll?)*
4. Now bend the cardboard to make one end steeper than the other. Release the small marble from the flat side of the cardboard to roll it to the other end. The marble cannot move up the steeper end.
5. Why can’t the marble go up the bend and escape out of the cardboard? *(What is this steep bend representing about black hole? How does the steeper bend of the cardboard affect the rolling speed of the marble?)*
6. Relate your answers (from step 3 and 5) to explain why things cannot escape when gravity is too extreme like that in black hole.
7. The small marble in this activity is like light and other objects that move in space and fall in black hole when they get too close. Light is the fastest thing in the Universe, and even that cannot escape from the gravity pull in black hole. From the 3 activities you’ve just done, what have you understood about black hole (what is it)?

***Part 4: What would happen if the Sun was replaced by a black hole of the same mass?***

Follow teacher’s instruction and demonstration.