

Mass of Black Hole	Diameter in kilometers
1.0	6.0
2.0	12.0
5.0	30.0
M	???

Although they are mysterious, black holes are actually very simple astronomical objects!

For black holes that don't spin, there is a simple relationship between the diameter of such a black hole, and its mass.

The masses of black holes,  $M$ , are usually given in multiples of the mass of our own sun, so '1.0' means that the black hole has exactly the same mass as our sun ( 2,000 trillion trillion tons!).

**Problem 1** – The table above gives the masses and diameters of a few black holes. What is the formula for the diameter of a black hole given its mass,  $M$ , if  $M$  is given in multiples of the mass of our sun ?

**Problem 2** – A planet was discovered orbiting just outside a black hole at a distance of 18,000 kilometers. What would you conclude about the mass of this black hole?

**Problem 3** - Suppose that for a black hole that spins, its diameter is 2 times that of a black hole of the same mass that doesn't spin. What is the formula for the diameter of such a spinning black hole given its mass?

**Problem 1** – The table above gives the masses and diameters of a few black holes. What is the formula for the diameter of a black hole given its mass,  $M$ , if  $M$  is given in multiples of the mass of our sun ?

**Answer:** The first two table entries give the formula  $D = 6 M$ , and the third entry for  $M = 5.0$ , gives  $D = 6 (5.0) = 30.0$  km, which verifies the formula.

**Problem 2** – A planet was discovered orbiting just outside a black hole at a distance of 18,000 kilometers. What would you conclude about the mass of this black hole?

**Answer:** If it is located just outside a black hole, then the radius of this black hole is 18,000 km so its diameter is 36,000 km. Then from the formula,  $36,000 = 6.0 M$ , so  $M = 6000$  times the sun's mass.

**Problem 3** - Suppose that for a black hole that spins, its diameter is 2 times that of a black hole of the same mass that doesn't spin. What is the formula for the diameter of such a spinning black hole given its mass?

Answer: The new table would look like this:

Mass of Black Hole	Diameter in kilometers
1.0	12.0
2.0	24.0
5.0	60.0
$M$	???

So the formula is now  $D = 12 M$ .