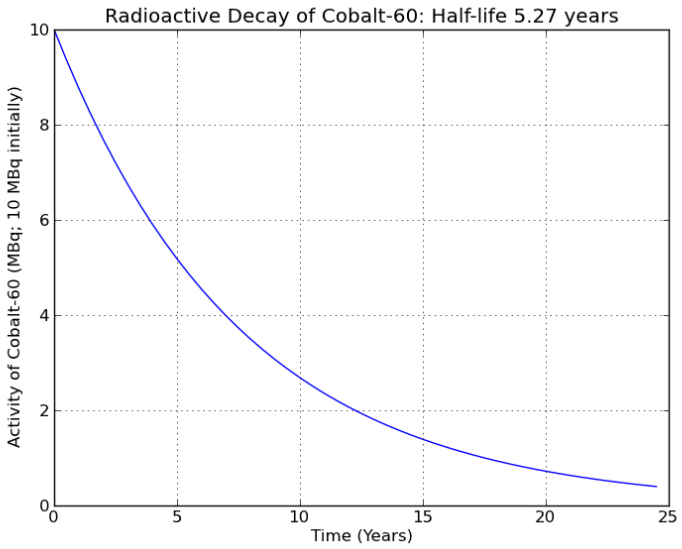
RADIATION EXPOSURE (25 满分)

感谢 glhezjnucn 同学贡献的翻译!

"Radioactive decay" is the process by which an unstable atom loses energy and emits ionizing particles - what is commonly refered to as radiation. Exposure to radiation can be dangerous and is very important to measure to ensure that one is not exposed to too terribly much of it.辐射衰变是不稳定原子失去能量并释放电离子的过程-这通常被称为辐射。接触辐射（暴露于辐射）可能是危险的，同时检测并确保人们不暴露于过量辐射（的环境）中变得重要。

The radioactivity of a material decreases over time, as the material decays. A radioactive decay curve describes this decay. The x-axis measures time, and the y-axis measures the amount of *activity* produced by the radioactive sample. 'Activity' is defined as the rate at which the nuclei within the sample undergo transitions - put simply, this measures how much radiation is emitted at any one point in time. The measurement of activity is called the Becquerel (Bq). Here is a sample radioactive decay curve:物质的辐射活性随着时间的流逝而减少，因为辐射物质在衰减。辐射衰减曲线用于描述这样的衰减过程。x轴表示时间，y轴表示辐射物质样品产生的辐射活性量。辐射的活性量定义为处于物质迁变的核的比率，它给出某一时刻所释放的辐射量。活性的度量称为Bq(理解为度量的单位即量纲)。如下是一个辐射衰减曲线的样例：



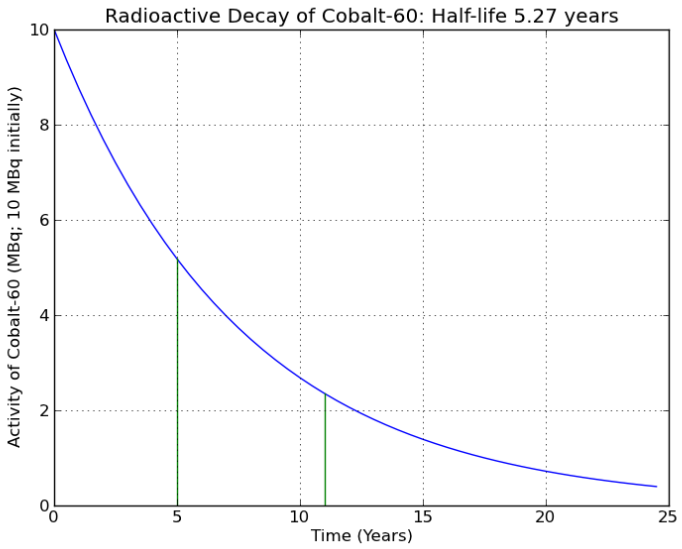
(Click on the pictures to view full-sized images)

Now here's the problem we'd like to solve. Let's say Sarina has moved into a new apartment. Unbeknownst to her, there is a sample of Cobalt-60 inside one of the walls of the apartment. Initially that sample had 10 MBq of activity, but she moves in after the sample has been there for 5 years. She lives in the apartment for 6 years, then leaves. How much radiation was she exposed to?

现在我们需要解决的问题是，假若Sarina搬进了新的房子，并不为她所知的是，房子的墙里有一个放射性钴-60样品。初始时，该样品具有10MBq(百万Bq)的辐射活性，但她是那个放射性物质在那里5年后才住进去的，她在那里住了6年，然后离开了。现在请问她接触了多少辐射?

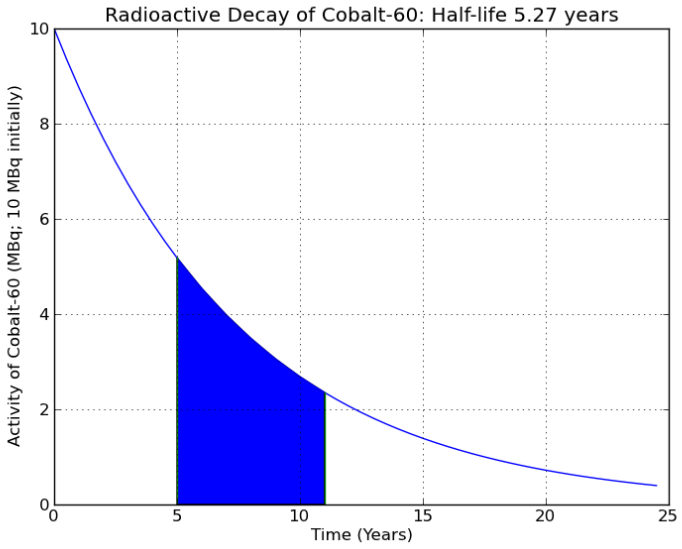
We can actually figure this out using the radioactive decay curve from above. What we want to know is her *total radiation exposure* from year 5 to year 11.

我们当然可以从上图的辐射曲线中计算出来。我们所需要知道的是从第5年到第11年她所接触的辐射总量。



Total radiation exposure corresponds to the area between the two green lines at time = 5 and time = 11, and under the blue radioactive decay curve. This should make intuitive sense - if the x axis measures time, and the y axis measures activity, then the area under the curve measures (time * activity) = MBq*years, or, approximately the total number of MBq Sarina was exposed to in her time in the radioactive apartment (technically, this result is the combination of gamma rays and beta particles she was exposed to, but this gets a bit complicated, so we'll ignore it. Sorry, physicists!).

辐射总量对应的是时间从5到11所对应的两条绿色线所对应区域的面积。这可以利用直觉-如果x轴是时间，y轴是活性度量，那么曲线下的面积(时间辐射活性)=MBq年，或者，近似的，就是Sarina在那段时间所接触的辐射量(技术地说，是由于伽玛射线与贝塔粒子，不过这太复杂了，因此我们忽略，抱歉,物理学家们！)

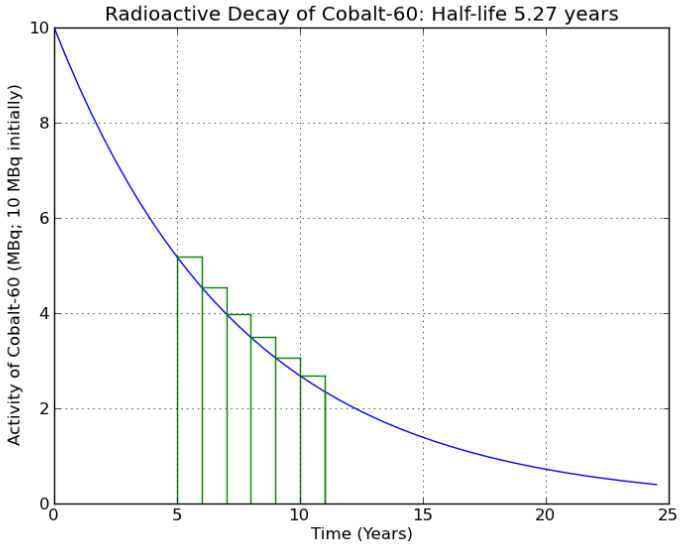


So far, so good. But, how do we calculate this? Unlike a simple shape - say a square, or a circle - we have no easy way to tell what the area under this curve is.

到此一切都不错。但是我们怎么来计算呢？不像简单的形状-如正方形，圆-我们没有简单的方法获得曲线下区域的面积。

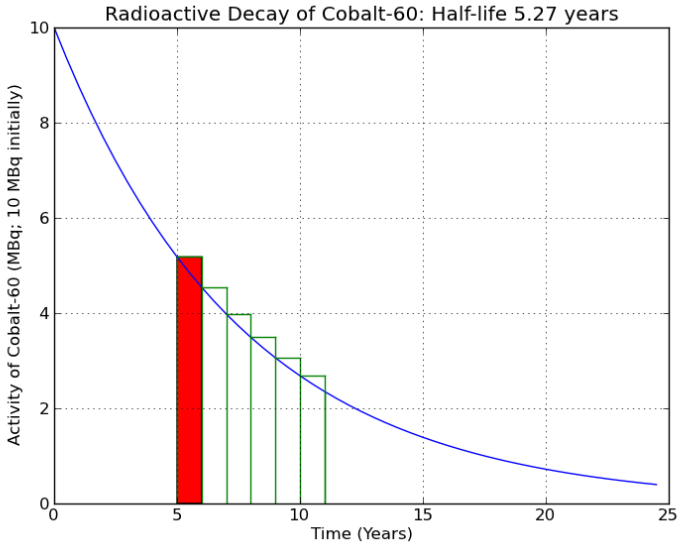
However, we have learned a technique that can help us here - *approximation*. Let's use an approximation algorithm to estimate the area under this curve! We'll do so by first splitting up the area into equally-sized rectangles (in this case, six of them, one rectangle per year):

不过，我们学过一种技术可以帮助我们-近似。我们用近似的方法来估计曲线下区域的面积！我们将这么来做，先将区域切成等尺寸（意指其中一边等长）的长方形，如下情形，是6个，每年一个长方形。



Once we've done that, we can figure out the area of each rectangle pretty easily. Recall that the area of a rectangle is found by multiplying the height of the rectangle by its width. The height of this rectangle:

当我们如此做了之后，我们可以非常简便的计算出每个长方形的面积。回忆一下长方形的面积是宽度乘以高度。而这里（红色的）长方形的高度：



is the value of the curve at 5.0. If the curve is described by a function, `f`, we can obtain the value of the curve by asking for `f(5.0)`.

是曲线在5.0处的值（函数值）.如果曲线由函数, f, 给出，我们可以用f(5.0)得到函数值.

```
f(5.0) = 5.181
```

The width of the rectangle is 1.0. So the area of this single rectangle is `1.0*5.181 = 5.181`. To approximate how much radiation Sarina was exposed to, we next calculate the area of each successive rectangle and then sum up the areas of each rectangle to get the total. When we do this, we find that Sarina was exposed to nearly 23 MBq of radiation (technically, her apartment was bombarded by 23e6 * 3.154e6 = 7.25e13 neutrons, for those interested...).

长方形的宽为1，因此面积（指红色的那个）为1.0*5.181 = 5.181. 为近似的计算Sarina接触的辐射总量，我们将逐次的面积加起来即可。当我们这么假设我们发现Sarina接触的辐射总量差不多是23 MBq (技术的说, 她的房子被大约23e6 * 3.154e6 = 7.25e13 个中子所轰炸, 如果有人感兴趣的话。).

Whether or not this will kill Sarina depends exactly on the type of radiation she was exposed to (see this link which discusses more about the ways of measuring radiation). Either way, she should probably ask her landlord for a substantial refund.

这是否足以使Sarina致命，这取决于她所接触辐射的类型（查看链接可以获知更多关于辐射量计算的信息）。或许她可以向房东索取大量的赔偿。

In this problem, you are asked to find the amount of radiation a person is exposed to during some period of time by completing the following function:

这个问题中，要求你计算某人在某个时间段所接触的辐射量，完成如下函数的设计：

```
def radiationExposure(start, stop, step):
    '''
    Computes and returns the amount of radiation exposed
    to between the start and stop times. Calls the
    function f (defined for you in the grading script)
    to obtain the value of the function at any point.

    start: integer, the time at which exposure begins
    stop: integer, the time at which exposure ends
    step: float, the width of each rectangle. You can assume that
      the step size will always partition the space evenly.

    returns: float, the amount of radiation exposed to
      between start and stop times.
    '''
```

To complete this function you'll need to know what the value of the radioactive decay curve is at various points. There is a function `f` that will be defined for you that you can call from within your function that describes the radioactive decay curve for the problem.

要完成这个函数的设计，你需要知道辐射曲线在不同点的值。有一个函数f已经为你准备好，你可以在你的函数内部直接调用，以获取辐射衰减曲线对应的问题。

You should implement this function on your own machine. Open a new Canopy Python file and title it "radiationExposure.py". Complete your work inside this file. Test your code well in Canopy, and when you are convinced it is correct, cut and paste your definition into this tutor window.

你应当在自己的机器上实现该函数，新建一个函数并取名为radiationExposure.py，在文件内完成你的工作。在Canopy中充分测试你的代码，当你确信它正确之后，复制粘贴到如下代码窗口。

Test Cases to Test Your Code With. Be sure to test these on your own machine - and that you get the same output! - before running your code on this webpage!

Click to See Test Cases

Assume that the curve function `f` is defined as follows:

```
def f(x):
    import math
    return 10*math.e**(math.log(0.5)/5.27 * x)
```

Test case 1:

```
>>> radiationExposure(0, 5, 1)
39.10318784326239
```

Test case 2:

```
>>> radiationExposure(5, 11, 1)
22.94241041057671
```

Test case 3:

```
>>> radiationExposure(0, 11, 1)
62.0455982538
```

Test case 4:

```
>>> radiationExposure(40, 100, 1.5)
0.434612356115
```

A note on these test cases: Your answers should be within 0.01 of the correct answer.

A Mathematical Note of Interest

The technique of finding the area under a curve is called *integration*. This comes to us from calculus. What we're doing in this problem is an approximation of finding the integral under the curve using the summation of rectangular areas known as a Riemann integral.

This approximation becomes more and more correct the smaller the width of the rectangles becomes.

So there you have it. If you've not learned calculus before, you've now got one of the basics - integration - covered!

```
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    start: integer, the time at which exposure begins
    stop: integer, the time at which exposure ends
    step: float, the width of each rectangle. You can assume that
      the step size will always partition the space evenly.

    returns: float, the amount of radiation exposed to
      between start and stop times.
    '''
    # FILL IN YOUR CODE HERE
```

未答复

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