Collected Mathematical Problems for First Year Students

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These are a series of mathematical problems which I have assembled to challenge first-year physics students from my back-catalogue of published and unpublished works. Many of these problems may appear harder than they are in actuality, whilst others may require fiendish insight - I will provide no distinction.

Answers should be both provided and resolved as integers unless otherwise specified. If you obtain a non-integer result, take a moment to reconsider your calculation.

1. Determine the value of x which satisfies the following equation:
$$\frac{9^{-1}}{81^{x}} = 9^{x^2}$$

2. Suppose I had a basket of green apples and red apples. Of the 100 total apples in the basket, 99% of them were red. Assuming that there are only red and green apples in the basket, how many red apples would I have to remove to change the percentage of red apples in the basket to 98%?

3. Find x, where:
$$\frac{9^{2x+1}3^{4-3x}}{27^{2-x}} = 9$$

4. On a hot summer's day, mathematicians at a gala are queuing at an ice cream van. The mathematician at the front of the queue requests that his cone be filled with two scoops of ice cream such that they perfectly fill the cone without exceeding the rim of the cone. They ask for one scoop to be 6.0 cm in diameter and the other to be 3.0 cm in diameter. Assuming that the scoops form uniform spheres and the cone has no thickness, find the height of the ice cream cone.

5. Solve for x:
$$2\log_2 x - \frac{1}{2}\log_2 x = 3$$

6. A chaise longue is a poncy kind of French chair most likely owned by Louis XVI just before he got 'the chop'. In the Palace of Versailles, Louis XVI wants to put a chaise longue in a long gallery such that it can be wheeled around a corner. Given that the corner angle is exactly 90 degrees, that the gallery has a uniform width of 3 m, and that all the chaise longues in France are 60 cm wide and a whole multiple of 10 cm long; how long is the longest chaise longue that Louis XVI can use in the long gallery?

7. Determine the non-zero value of x which satisfies:
$$\sqrt{x} + \sqrt{x} = x$$

8. A 10 pence coin is made to roll along the edge of a 1 pound coin. Given that a 10 pence coin has a diameter of 28.5 mm and that a 1 pound coin has twelve sides, each measuring 6.00 mm; calculate how many revolutions the 10 pence coin passes through as it makes one full revolution of the 1 pound coin. (Give your answer to the nearest fifth of a whole rotation.)

9. Solve for x:
$$\frac{x\left(x\left(x\left(x-20\right)+160\right)-640\right)+1280\right)-1024}{\left(x-4\right)^4} = 5$$

10. One day, Leonardo Fibonacci is playing poker with a standard deck of playing cards and asks himself how many arrangements of the 52 cards leads to all of the cards of the 4 suits being separated – regardless of their individual order. Given that there are 13 cards in each suit and no jokers, what is the solution to Fibonacci's problem? (A modern calculator will give the answer in standard form to nine significant figures, Fibonacci's abacus probably would not. I suggest you use the former.)

11. Solve for x:
$$2 = \sqrt{x\sqrt{x\sqrt{x\cdots}}}$$