Mathematics Interview Questions

The Student Room

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These questions are from Oxbridge Maths Interview Questions. Thanks to the person who compiled them!

1. Differentiate x^x.
2. Integrate $\cos^2(x)$ and $\cos^3(x)$.
3. What is the square root of i?
4. If I had a cube and six colours and painted each side a different colour, how many (different) ways could I paint the cube? What if I had n colours instead of 6?
5. Prove that $\sqrt{2}$ is irrational.
6. Integrate $\ln(x)$.
7. Sketch the curve $(y^2-2)^2+(x^2-2)^2=2$. What does it look like?
8. 3 girls and 4 boys are standing in a circle. What is the probability that two girls are together but one is not with them?
9. Prove that $1+\frac{1}{2}+\frac{1}{3}+\cdots+\frac{1}{1000}<10$.
10. Is there a number N such that $7/N^2=3$?
11. What is the integral of $x^2\cos^3(x)$?
12. How many squares can be made from a grid of ten by ten dots (ignoring diagonal squares)?
13. Integrate $\tan(x)$.
14. Pascal's triangle: prove that every number in the triangle is the sum of the two numbers above it.
15. Integrate $\frac{1}{1-\ln(x)}$.
16. Sketch x^x.

17. Prove $4n - 1$ is a multiple of 3.
18. How many ways are there to go from one vertex of a cube to the opposite vertex without retracing edges?
19. What shape results if the cube is cut in half from diagonally opposite vertices?
20. Draw $x\ln(x)$.
21. Integrate and differentiate $x\ln(x)$.
22. Draw $\sin(\frac{1}{x})$.
23. Differentiate x^x.
24. What do you know about triangles?
25. Find a series of consecutive integers such that the sum of the series is a power of 2.
26. Prove Ptolemy's Theorem.
27. Solve $mx = \sin(x)$ for different values of m.
28. Integrate $|\sin^n(x) + \cos^n(x)|$ between 0 and 2π for $n = 1, 2$.
29. $x^2 + y^2 = z^2$. Prove xyz is a multiple of 60.
30. A game involves taking turns to eat chillies. There are 5 mild and 1 hot chilli. Assuming the game ends when the hot chilli is eaten, what is the probability of eating the hot chilli if you go first?
31. Find real roots of $kx^4 = x^3 - x$ for $k = 0$. Sketch the graph for small and large k, and approximate the real roots.
32. Sketch $f(x) = (x - R(x))^2$, where $R(x)$ is x rounded up or down. Then sketch $g(x) = f(\frac{1}{x})$.
33. Differentiate $\frac{1}{1+\frac{1}{1+\frac{1}{1+\frac{1}{1+x}}}}$.
34. Sketch graphs of $\frac{1}{x}$, $\frac{1}{x^2}$, and $\frac{1}{1+x^2}$.
35. Integrate $\frac{1}{1+x^2}$.
36. Integrate $e^x x^2$ between limits of 1 and 0.
37. Integrate x^{-2} between limits of 1 and -1. Why is the answer -2 and not infinity?
38. Write down a 3-digit number and repeat it next to itself, e.g., 145145. Why is this number divisible by 13?

39. You are given a triangle with a fixed perimeter, and you want to maximize the area. What shape will it be? Prove it.

40. Integrate $\frac{1}{x+x^3}$, $\frac{1}{1+x^3}$, and $\frac{1}{1+x^n}$.

41. How many zeros are in 100!?

42. Prove that the angle at the centre of a circle is twice that at the circumference.

43. How many ways can you color three equal portions of a disc?

44. Integrate $\frac{1}{9+x^2}$.

45. Draw $y = e^x$, $y = kx$, and graph the number of solutions of $e^x = kx$. Find the value of k where there is only 1 solution.

46. Solve $ab = ba$ for all real a and b.

47. What is the probability of winning in a game where two players roll a die and the first to roll a six wins?

48. Sketch $y = x^3$ and $y = x^5$ on the same axis.

49. Prove there is no integer solution to $a^2 + b^2 = c^2$ where a and b are both odd.

50. There is a game with 2 players (A & B) who take turns to roll a die, and they must roll a six to win. What is the probability of person A winning?

51. Sketch $y = x^3$ and $y = x^5$ on the same axis.

52. What would the two sides of a rectangle (a and b) be to maximize the area if $a + b = 2C$ (where C is a constant)?

53. Can 1000003 be written as the sum of two square numbers?

54. Show that when you square an odd number, you always get one more than a multiple of 8.

55. Prove that $1 + \frac{1}{2} + \frac{1}{3} + \frac{1}{4} + \ldots$ equals infinity.

56. Prove that for $n \in \mathbb{Z}$, $n > 2$, $n(n+1) > (n+1)n$.

57. Prove that $\sqrt{3}$ is irrational.

58. What are the possible unit digits for perfect squares?

59. What are the possible remainders when a cube is divided by 9?

60. Prove that 801,279,386,104 cannot be written as the sum of three cubes.

61. Sketch $y = \frac{\ln(x)}{x}$ and find the maximum.

62. What is the probability of flipping n consecutive heads on a fair coin? What about an even number of consecutive heads?

63. Two trains start 30 km apart and travel towards each other. They meet after 20 minutes. If the faster train chases the slower one (starting 30 km apart), they meet after 50 minutes. How fast are the trains moving?

64. A 10-digit number is made up of only 5s and 0s. It is also divisible by 9. How many possibilities are there for the number?

65. There is a set of numbers whose sum is equal to the sum of their squares. What is larger: the sum of their cubes or the sum of their fourth powers?

66. Draw e^{-x^2}.

67. Draw $\cos(x^2)$.

68. What are the last two digits of the number formed by multiplying all the odd numbers from 1 to 1,000,000?

69. Prove that $1! + 2! + 3! + \ldots$ has no square values for $n > 3$.

70. How many zeros at the end of 365!?

71. Integrate $x \sin^2(x)$.

72. Draw e^x, $\ln(x)$, and $y = x$. As x tends to infinity, what does $\frac{\ln(x)}{x}$ tend to?

73. Define the term 'prime number'.

74. Find a method to check if a number is prime.

75. Prove that for $a^2 + b^2 = c^2$, a and b cannot both be odd.

76. What are the conditions for which a cubic equation has two, one, or no solutions?

77. What is the area between two circles, radius one, that go through each other's centers?

78. If every term in a sequence S is defined by the sum of all previous terms, give a formula for the nth term.

79. Is 0.9 recurring equal to 1? Why? Prove it.

80. Why are there no Pythagorean triples in which both x and y are odd?

81. Draw graphs of $\sin(x)$, $\sin(2x)$, and $\sin(3x)$.

82. Prove the infinity of primes. Also, prove the infinity of primes of the form $4n + 1$.

83. Differentiate $\cos^3(x)$.

84. Show $(x-a)^2 - (x-b)^2 = 0$ has no real roots if $a \neq b$ in as many ways as you can.

85. Hence show:

    - $(x-a)^3 + (x-b)^3 = 0$ has 1 real root,
    - $(x-a)^4 + (x-b)^4 = 0$ has no real roots,
    - $(x-a)^4 + (x-b)^4 = (b-a)^4$ has 2 real roots.

86. Find the values of all the derivatives of e^{-1/x^2} at $x = 0$.

87. Show that $n^5 - n^3$ is divisible by 12.

88. If I have a chance p of winning a point in tennis, what's the chance of winning a game?

89. Explain what integration is.

90. If n is a perfect square and its second last digit is 7, what are the possibilities for the last digit of n, and can you prove this will always be the case?

91. How many subsets can you form from a set of n numbers?

92. Prove that $\frac{a+b}{2} > \sqrt{ab}$ where $a > 0$, $b > 0$, and $a \neq b$, i.e., prove that the arithmetic mean is greater than the geometric mean.

93. What is 0^0 (i.e., is it 0 or 1)? Solve it by drawing x^x.

94. If $f(x+y) = f(x)f(y)$, show that $f(0) = 1$.

95. Suggest prime factors of 612,612,503,503.

96. How many faces are there on an icosahedron?

97. Integrate $\frac{1}{1+\sin(x)}$.

98. What is the greatest value of n for which 20! is divisible by 2^n?

99. Prove that the product of four consecutive integers is divisible by 24.