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Question: Find the big-Theta notation as a function of n of the following...

Find the big-Theta notation as a function of n of the following program:

```

q, s ← 1, 1
while s < n
    for k ← 1 to s
        p ← 1
        while p ≤ k
            p ← 2 * p
        q ← q + 1
    s ← q * q

```

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Expert Answer

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Step-by-step

FIRST STEP | ALL STEPS | ANSWER ONLY

Step 1 of 2 ^

The best way to find the complexity (theta notation) of a code is to dry run the code for some initial values then try to generalize it.

Dry run of the given code:

Explanation

Please refer to solution in this step.

Step 2 of 2 ^

DRY RUN:

```

1
2 ----- OUTER WHILE LOOP -----
3
4 n = a large value
5 initially q = 1 and s = 1
6
7 for the outer while loop, the value of q will increase by 1 in every iteration
8
9 the value of q in every iteration will be like = 1,2,3,4,5,6,7.....m ( m times )
10
11 the s will increase like s = 1*1 , 2*2, 3*3, 4*4, 5*5,.....,m*m
12

```

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13 the loop will
 14
 15 $m^2 = n$  Home Study tools  My courses  My books My folder Career Life
 16
 17 $m = \sqrt{n}$
 18
 19 So the running time of outer while loop is $= \sqrt{n}$
 20
 21 ----- INNER FOR LOOP -----
 22
 23 the inner loop is running for $k = 1$ to s (for every value of s)
 24
 25 iteration of this inner for loop will be like (for every value of s)
 26
 27
 28 1 to 1^2 (1^2)
 29
 30 1 to 2^2 (2^2)
 31
 32 1 to 3^2 (3^2)
 33
 34 ..
 35 ..
 36 ..
 37
 38 1 to $\sqrt{n} * \sqrt{n}$
 39
 40
 41 $= 1^2 + 2^2 + 3^2 + 4^2 + \dots + \sqrt{n}^2$
 42
 43 using the formula $1^2 + 2^2 + \dots + n^2 = \frac{n(n+1)(2n+1)}{6}$
 44
 45 $= \sqrt{n}(\sqrt{n} + 1)(2\sqrt{n} + 1) / 6$
 46
 47 So the running time of inner for loop $= \sqrt{n}(\sqrt{n} + 1)(2\sqrt{n} + 1) / 6$
 48
 49 ----- INNER WHILE LOOP -----
 50
 51
 52 the inner while loop is running for $p = 1$ to k (for every value of k)
 53
 54 because in every iteration the value of p is increasing by a multiplying constant factor 2 so the time complexity will be a logarithmic function
 55
 56 iteration of this inner while loop will be like (for every value of k)
 57
 58 1 to $\log(1^2) == 1$ to $2\log 1$ (because $\log m^n = n \log m$)
 59
 60
 61 1 to $\log(2^2) == 1$ to $2\log 2$
 62
 63 1 to $\log(3^2) == 1$ to $2\log 3$
 64
 65 ..
 66 ..
 67 ..
 68
 69 1 to $\log(\sqrt{n}^2) == 1$ to $2\log(\sqrt{n})$
 70
 71
 72 $= 2\log 1 + 2\log 2 + 2\log 3 + \dots + 2\log(\sqrt{n})$
 73
 74 $=$ take 2 as common
 75
 76 $= 2 (\log 1 + \log 2 + \log 3 + \dots \log(\sqrt{n}))$
 77
 78 using the property $\log x + \log y = \log x*y$
 79
 80 $= 2 (\log(1+2+3+\dots+\sqrt{n}))$
 81
 82 so the running time will be :
 83
 84 $= 2 (\log((\sqrt{n}(\sqrt{n} + 1))/2))$ (because $1+2+3+4+\dots+n = \frac{n(n+1)}{2}$)
 85
 86 -----
 87
 88 Because all the loops are nested loop
 89
 90 So the running time complexity of this code is
 91
 92
 93 $\sqrt{n} * (\sqrt{n}(\sqrt{n} + 1)(2\sqrt{n} + 1) / 6) * (2 (\log((\sqrt{n}(\sqrt{n} + 1))/2))$
 94
 95
 96 Theta notation =
 97 $\theta (\sqrt{n} * (\sqrt{n}(\sqrt{n} + 1)(2\sqrt{n} + 1) / 6) * (2 (\log((\sqrt{n}(\sqrt{n} + 1))/2)))$
 98
 99

Explanation

Please refer to solution in this step.

As described in the

1) / 6) * (2

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Q: Consider Above Program Use big-Theta notation, the running time of the inner while loop, as a function of q is $\theta(q)$. a. Express the running time of the outer while loop as a sum. b. Express the total running time of the program, as a function (as simplified as possible) of n.

A: [See answer](#)

Q: Given that the number of iterations of the outer loop is approximately $\lg(n)$ for the following Program: Express, using big-Theta notation, the total running time of the program, as a function (as simplified as possible) of n.

A: [See answer](#)

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