

Theory of Functions of a Complex Variable I

Instructions Solve six of the following seven problems. Please write your solutions on your own paper.

These problems should be treated as essay questions. A problem that says “find” or that asks a question requires an explanation to support the answer. Please explain your reasoning in complete sentences.

1. Find the first two nonzero terms of the Laurent series of $\frac{1}{z^2(e^z - e^{-z})}$ that is valid in the punctured disk where $0 < |z| < \pi$.

Solution. This problem is number 5 on page 5 in Section 4.1.

Since

$$\begin{aligned} e^z - e^{-z} &= (1 + z + \frac{1}{2!}z^2 + \frac{1}{3!}z^3 + \dots) - (1 - z + \frac{1}{2!}z^2 - \frac{1}{3!}z^3 + \dots) \\ &= 2(z + \frac{1}{3!}z^3 + \dots), \end{aligned}$$

it follows that

$$\begin{aligned} \frac{1}{z^2(e^z - e^{-z})} &= \frac{1}{2z^3} \cdot \frac{1}{1 + \frac{1}{6}z^2 + \dots} = \frac{1}{2z^3} \cdot (1 - \frac{1}{6}z^2 + \dots) \\ &= \frac{1}{2z^3} - \frac{1}{12z} + \dots. \end{aligned}$$

A different method is shown in the textbook.

2. Classify each isolated singularity of the function $\frac{1}{z^2(z+1)} + \sin\left(\frac{1}{z}\right)$: is the singularity removable? essential? a pole?

Solution. This problem is number 10(b) on page 6 in Section 4.1.

There is an essential singularity at 0 and a simple pole at -1 . (Also there is a removable singularity at ∞ .)

3. Use the residue theorem to prove that

$$\frac{1}{2\pi} \int_0^{2\pi} (\sin \theta)^{2n} d\theta = \frac{(2n)!}{(n! 2^n)^2}$$

when n is a natural number.

Solution. This problem is number 4(g) on page 11 in Section 4.2.

Theory Of Functions Of A Complex Variable Volume 2

F. R. Gantmacher



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