Continuity and Differentiability

Standard difficulty · 20 questions · 40 marks · Time: 36 minutes

Name: _____ Date: _____ Score: ____ / 40

Show your working for Sections B and C. Answers are on the last page — try every question first!

Section A — Choose the correct answer — 8 × 1 = 8 marks

1. f(x) = kx + 9 for x ≤ −1, and f(x) = x^2 + 8 for x > −1. f is continuous at x = −1 when k equals:

(a) 0 **(b)** −18 **(c)** 2 **(d)** 1

2. The derivative of sin(6x − 8) with respect to x is:

(a) −6 cos(6x − 8) **(b)** 6 sin(6x − 8) **(c)** cos(6x − 8) **(d)** 6 cos(6x − 8)

3. If y = $(x + 5)^3$, then dy/dx at x = 0 is:

(a) 76 **(b)** 125 **(c)** 75 **(d)** 375

4. If $5x^2 + 6y^2 = 55$, then dy/dx is:

(a) 5x/(6y) **(b)** −5x/(6y) **(c)** −6y/(5x) **(d)** −10x/(6y)

5. f is continuous at x = c when:

(a) f is defined only at c **(b)** f(c) = 0

(c) lim (x → c) f(x) = f(c) **(d)** f′(c) = 0

6. If $x = 3t^2$ and y = −4t, then dy/dx at t = −3 is:

(a) 2/9 **(b)** 4/9 **(c)** 9/2 **(d)** −2/9

7. If $y = -4x^4 + 3x^3 + 2x^2 + x - 6$, then d^2y/dx^2 at x = 0 is:

(a) 4 **(b)** 8 **(c)** 1 **(d)** −4

8. Assertion (A): f(x) = |x − 7| is differentiable at x = 7.
Reason (R): The left-hand and right-hand derivatives of |x − 7| at x = 7 are different.

(a) Both A and R are true, and R is the correct explanation of A.

(b) Both A and R are true, but R is not the correct explanation of A.

(c) A is true, but R is false.

(d) A is false, but R is true.

Section B — Short answer — 8 × 2 = 16 marks

9. Is f continuous at x = 1, where f(x) = 5x + 9 for x ≤ 1 and f(x) = 2x + 13 for x > 1?

10. Find k so that f(x) = $(x^5 + 1024)/(x + 4)$ for x ≠ −4, and f(−4) = k, is continuous at x = −4.

11. Differentiate $\tan^{-1}(3x)$ with respect to x.

12. Find dy/dx if $4x^2 + 6xy + 3y^2 = 40$.

13. Use logarithmic differentiation to find dy/dx if $y = (x + 4)(x + 1)(x + 7)$.

14. Find dy/dx if $x = 7\cos\theta$ and $y = 7\sin\theta$.

15. If $y = \sin 4x - \cos 4x$, find λ such that $d^2y/dx^2 = \lambda y$.

16. Differentiate $y = 4 \times 9^x + x^4$ with respect to x.

Section C — Word problems — 4 × 4 = 16 marks

17. Find a and b so that f is continuous: $f(x) = 18$ for $x \le -3$, $f(x) = ax + b$ for $-3 < x < 3$, and $f(x) = -6$ for $x \ge 3$.

18. Find dy/dx if $y = (x + 5)^4(x - 8)^5/(x + 1)^2$.

19. If $y = 8e^{4x} + 3e^x$, show that $d^2y/dx^2 - 5\,dy/dx + 4y = 0$.

20. If $x = 4t^2$ and $y = 8t$, find dy/dx and d^2y/dx^2 in terms of t, and their values at $t = 1$.

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Answer key

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Q	Answer	Working
1	**(a) 0**	$k(-1) + 9 = 9$
2	**(d) 6 cos(6x − 8)**	chain rule: differentiate the outside, then multiply by the derivative of the inside
3	**(c) 75**	$dy/dx = 3(x + 5)^2 = 3 \times 5^2$
4	**(b) −5x/(6y)**	$10x + 12y\,(dy/dx) = 0$
5	**(c) lim (x → c) f(x) = f(c)**	—
6	**(a) 2/9**	$dy/dx = -4 \div 6t$
7	**(a) 4**	$d^2y/dx^2 = -48x^2 + 18x + 4$
8	**(d) A is false, but R is true.**	A is false: the left-hand derivative at x = 7 is −1 and the right-hand derivative is 1. R is true.
9	**No: LHL = 14 but RHL = 15**	left limit and f(1) from 5x + 9, right limit from 2x + 13
10	**k = 1,280**	$\lim (x^n - a^n)/(x - a) = na^{n-1} = 5 \times (-4)^4$
11	**$3/(1 + 9x^2)$**	chain rule
12	**$dy/dx = -(4x + 3y)/(3x + 3y)$**	$8x + 6y + (6x + 6y)\,dy/dx = 0$
13	**$dy/dx = (x + 4)(x + 1)(x + 7)[1/(x + 4) + 1/(x + 1) + 1/(x + 7)]$**	$\log y = \log(x + a) + \log(x + b) + \log(x + c)$
14	**$dy/dx = -\cot \theta$**	$dy/d\theta = 7 \cos \theta$, $dx/d\theta = -7 \sin \theta$
15	**$\lambda = -16$**	d^2/dx^2 of sin 4x is −16 sin 4x
16	**$dy/dx = 4 \times 9^x \log 9 + 4x^3$**	$d/dx\ a^x = a^x \log a$
17	**a = −4, b = 6**	$(-3)a + b = 18$ and $3a + b = -6$
18	**$dy/dx = (x + 5)^4(x - 8)^5/(x + 1)^2 \times [4/(x + 5) + 5/(x - 8) - 2/(x + 1)]$**	$\log y = 4 \log(x + 5) + 5 \log(x - 8) - 2 \log(x + 1)$
19	**$d^2y/dx^2 - 5\,dy/dx + 4y = 0$ (shown)**	$dy/dx = 32e^{4x} + 3e^x$; $d^2y/dx^2 = 128e^{4x} + 3e^x$
20	**$dy/dx = 1/(t)$; $d^2y/dx^2 = -1/(8t^3)$; at t = 1: 1 and −1/8**	$d^2y/dx^2 = d/dt(dy/dx) \div dx/dt$

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