Application of Derivatives

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. The radius of a circle grows at 3 cm/s. When the radius is 3 cm, its area grows at:

(a) 18π cm^2/s **(b)** 36π cm^2/s **(c)** 27π cm^2/s **(d)** 9π cm^2/s

2. $f(x) = 2x^3 - 27x^2 + 120x + 6$ is strictly increasing on:

(a) $(4, 5)$ **(b)** $(-\infty, -5) \cup (-4, \infty)$

(c) $(-\infty, 4) \cup (5, \infty)$ **(d)** $(-\infty, 5)$

3. The slope of the tangent to $y = -x^3 - 5x^2 + x - 9$ at $x = 3$ is:

(a) -56 **(b)** -78 **(c)** 56 **(d)** -55

4. The maximum value of $f(x) = -2x^2 + 2$ is:

(a) 0 **(b)** 2 **(c)** -2 **(d)** 3

5. f is strictly increasing on an interval if, on that interval:

(a) $f(x) > 0$ **(b)** $f'(x) < 0$ **(c)** $f'(x) > 0$ **(d)** $f'(x) = 0$

6. $f(x) = 2x^3 - 9x^2 - 5$ has a local minimum at $x =$

(a) 4 **(b)** 0 **(c)** 3 **(d)** -3

7. The slope of the normal to $y = -2x^2 - 5x$ at $x = 4$ is:

(a) $-1/21$ **(b)** -21 **(c)** $1/21$ **(d)** 21

8. Assertion (A): $f(x) = 5x^3 + 8x + 3$ is strictly increasing on R.
Reason (R): A function with $f'(x) > 0$ at every point of an interval is strictly decreasing there.

(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. Air is pumped into a spherical balloon at 25 cm^3/s. How fast is the radius increasing when the radius is 15 cm?

10. Find the intervals on which $f(x) = 2x^3 - 24x^2 + 90x + 7$ is strictly increasing and strictly decreasing.

11. Find the equation of the tangent to $y = 3x^3 + 3x^2 - 3x - 5$ at the point where $x = 3$.

12. Find the equation of the normal to $y = x^2 + 2x - 6$ at the point where $x = 2$.

13. Find the local maximum and local minimum values of $f(x) = 2x^3 - 3x^2 - 36x + 6$.

14. Find the absolute maximum and absolute minimum values of $f(x) = 2x^3 + 12x^2 + 18x + 5$ on $[-5, 0]$.

15. The total revenue in rupees from selling x units is $R(x) = 9x^2 + 18x + 76$. Find the marginal revenue when $x = 15$.

16. Find the point on $y = x^2 + x + 8$ where the tangent is parallel to the line $y = 11x + 7$.

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

17. An open box is made from a square sheet of cardboard of side 78 cm by cutting equal squares from each corner and folding up the sides. Find the side of the square to be cut off for the box to have the greatest volume, and that volume.

18. Two positive numbers have sum 84. Find them if the product of the square of the first and the second is as large as possible, and the largest value.

19. A farmer has 36 m of fencing to enclose a rectangular field along a straight river; no fence is needed along the river. Find the dimensions that give the largest area, and that area.

20. A ladder 17 m long leans against a wall. Its foot is pulled away from the wall at 3 m/s. How fast is the top sliding down the wall when the foot is 8 m from the wall?

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Answer key

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Q	Answer	Working
1	**(a) 18π cm^2/s**	differentiate the formula with respect to t
2	**(c) $(-\infty, 4) \cup (5, \infty)$**	$f'(x) = 6(x - 4)(x - 5)$
3	**(a) −56**	$dy/dx = -3x^2 - 10x + 1$
4	**(b) 2**	$f'(x) = 0$ at $x = 0$; $f(0) = 2$
5	**(c) $f'(x) > 0$**	—
6	**(c) 3**	$f'(x) = 6x(x - 3)$; $f''(3) > 0$
7	**(c) 1/21**	slope of tangent = −21; normal slope = $-1/(-21)$
8	**(c) A is true, but R is false.**	A is true: $f'(x) = 15x^2 + 8 > 0$ for every x. R is false.
9	**1/(36π) cm/s**	$dV/dt = 4\pi r^2 \, dr/dt \Rightarrow dr/dt = 25/(4\pi \times 225)$
10	**Increasing on $(-\infty, 3) \cup (5, \infty)$; decreasing on (3, 5)**	$f'(x) = 6(x - 3)(x - 5)$
11	**y = 96x − 194**	point (3, 94), slope 96
12	**x + 6y = 14**	point (2, 2); tangent slope 6; normal: $(x - 2) + 6(y - 2) = 0$
13	**local maximum 50 at x = −2; local minimum −75 at x = 3**	$f'(x) = 6(x + 2)(x - 3)$; $f''(x) = 12x - 6$
14	**maximum 5 at x = −3 and 0; minimum −35 at x = −5**	$f(-5) = -35$, $f(-3) = 5$, $f(-1) = -3$, $f(0) = 5$
15	**Rs 288**	$R'(x) = 18x + 18$
16	**(5, 38)**	$dy/dx = 2x + 1 = 11$
17	**13 cm; 35,152 cm^3**	$V = x(78 - 2x)^2$; $V' = 0$ at $x = 13$ ($x = 39$ gives no box); $V'' < 0$ there
18	**56 and 28; largest value 87,808**	write the product in one variable, set its derivative to zero, and check the second derivative
19	**9 m by 18 m (the side along the river is 18 m); 162 m^2**	$A = x(36 - 2x)$; $A' = 36 - 4x = 0$ at $x = 9$
20	**8/5 m/s**	$x^2 + y^2 = 289$; when $x = 8$, $y = 15$; $dy/dt = -(x/y) \, dx/dt = -(8/15) \times 3$

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