

How to use this sheet. Every question reduces to one of four tasks: find where f' is positive or negative, apply the second derivative test at a critical point, evaluate f' at a point for a tangent or normal, or differentiate a geometric formula with respect to time for a related rate. Identify which of the four applies before doing anything else.

Quick reference — Increasing where $f' > 0$, decreasing where $f' < 0$ · $f''(c) < 0$ max, $f''(c) > 0$ min ·
Tangent slope = $f'(a)$, normal slope = $-1/f'(a)$ · $f(a+h) \approx f(a) + h \cdot f'(a)$

Section A · Level 1

Six questions. None should take more than twenty seconds.

1. A function f is said to be increasing on an interval if, for that interval:

- (1) $f(x) < 0$ (2) $f(x) > 0$ (3) $f'(x) = 0$ (4) $f''(x) > 0$

2. The function $f(x) = x^2 - 4x + 3$ is increasing when:

- (1) $x < 2$ (2) $x > 2$ (3) $x < -2$ (4) $x > -2$

3. A point where $f'(x) = 0$ or $f'(x)$ does not exist is called a:

- (1) Point of inflection (2) Critical point (3) Asymptote (4) Discontinuity

4. In the second derivative test, if $f'(c) = 0$ and $f''(c) < 0$, then $x = c$ is a:

- (1) Local minimum (2) Local maximum (3) Point of inflection (4) Not an extremum

5. In the second derivative test, if $f'(c) = 0$ and $f''(c) > 0$, then $x = c$ is a:

- (1) Local maximum (2) Local minimum (3) Point of inflection (4) Not an extremum

6. If $f'(c) = 0$ and $f''(c) = 0$, the second derivative test:

- (1) Confirms a maximum (2) Confirms a minimum (3) Is inconclusive (4) Proves no extremum exists

Section B · Level 2

Five questions. The tangent slope is always the derivative at that point.

7. The slope of the tangent to a curve $y = f(x)$ at the point $x = a$ is:

- (1) $f(a)$ (2) $f'(a)$ (3) $f''(a)$ (4) a

8. The slope of the normal to a curve at a point where the tangent has slope m is:

- (1) m (2) $-m$ (3) $1/m$ (4) $-1/m$

9. The slope of the tangent to the curve $y = x^2$ at the point $x = 2$ is:

- (1) 2 (2) 4 (3) 8 (4) 16

10. The slope of the normal to the curve $y = x^2$ at the point $x = 2$ is:

- (1) 4 (2) -4 (3) $\frac{1}{4}$ (4) $-\frac{1}{4}$

11. Using differentials, the approximate value of $\sqrt{25.2}$ is closest to:

- (1) 5.00 (2) 5.01 (3) 5.02 (4) 5.05

Section C · Level 3

Nine questions. Differentiate the connecting equation with respect to time for a rate question.

12. A stone is dropped into a pond, and circular ripples spread outward. If the radius increases at 2 cm/s, the rate at which the area increases when the radius is 5 cm is:

- (1) $10\pi \text{ cm}^2/\text{s}$ (2) $20\pi \text{ cm}^2/\text{s}$ (3) $25\pi \text{ cm}^2/\text{s}$ (4) $5\pi \text{ cm}^2/\text{s}$

13. The radius of a sphere is increasing at 2 cm/s. The rate of increase of its volume when the radius is 3 cm is:

- (1) $36\pi \text{ cm}^3/\text{s}$ (2) $72\pi \text{ cm}^3/\text{s}$ (3) $48\pi \text{ cm}^3/\text{s}$ (4) $24\pi \text{ cm}^3/\text{s}$

14. The function $f(x) = -x^2 + 4x + 1$ attains its maximum value at $x =$

- (1) 1 (2) 2 (3) 3 (4) 4

15. The maximum value of the function $f(x) = -x^2 + 4x + 1$ is:

- (1) 1 (2) 3 (3) 5 (4) 7

16. A rectangle is to be inscribed with a given perimeter so as to have maximum area. The rectangle that achieves this is always a:

- (1) Golden rectangle (2) Square (3) Rectangle twice as long as it is wide (4) Rectangle with one side zero

17. The function $f(x) = x^3 - 3x$ has critical points at:

- (1) $x = 0$ only (2) $x = 1$ and $x = -1$ (3) $x = 3$ only (4) $x = 1$ only

18. For $f(x) = x^3 - 3x$, the point $x = -1$ is a:

- (1) Local minimum (2) Local maximum (3) Point of inflection (4) Not an extremum

19. For $f(x) = x^3 - 3x$, the point $x = 1$ is a:

- (1) Local minimum (2) Local maximum (3) Point of inflection (4) Not an extremum

20. A curve is said to have a point of inflection where:

- (1) $f'(x) = 0$ only (2) $f''(x)$ changes sign (3) $f(x) = 0$ (4) The curve crosses the x-axis

Answer key: 1. (2) 2. (2) 3. (2) 4. (2) 5. (2) 6. (3) 7. (2) 8. (4) 9. (2) 10. (4) 11. (3) 12. (2) 13. (2) 14. (2) 15. (3) 16. (2) 17. (2) 18. (2) 19. (1) 20. (2)

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