# NCERT Solutions Class 12 Maths
# Chapter 6: Application of Derivatives
# Exercise 6.1

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**Quick Summary:** In NCERT Solutions Class 12 Maths Chapter 6 Exercise 6.1, students learn fundamental concepts of rate of change and related rates problems involving geometric shapes. This exercise covers the application of derivatives to find how one quantity changes with respect to another, which is essential for CBSE Board exams and forms the foundation for optimization problems in calculus.

**Key Takeaways:**

- Master the chain rule for related rates: (dy)/(dt) = (dy)/(dx) · (dx)/(dt)
- Apply rate of change to geometric figures like circles, cubes, and spheres with formulas for area and volume
- Understand the connection between instantaneous rate of change and derivatives for real-world applications
- Practice step-by-step problem solving techniques that are frequently tested in CBSE Class 12 board examinations

## Complete Solutions

## Question 1

QUESTION

Find the rate of change of the area of a circle with respect to its radius r when

(a) r = 3\text cm

(b) r = 4\text cm

SOLUTION

This question tests our understanding of how to find the rate of change of one quantity with respect to another, specifically the area of a circle with respect to its radius, using derivatives.

**Step 1: Recall the formula for the area of a circle**

The area of a circle with radius is given by:

**Step 2: Differentiate the area with respect to the radius**

We need to find . Differentiating both sides of the area formula with respect to , we get:

Since is a constant, we have:

Using the power rule for differentiation, , we get:

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**(a) Find the rate of change when cm**

Substitute into the expression for :

Therefore, the rate of change of the area with respect to the radius when cm is cm/cm.

**Final Answer (a):**

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**(b) Find the rate of change when cm**

Substitute into the expression for :

Therefore, the rate of change of the area with respect to the radius when cm is cm/cm.

**Final Answer (b):**

**Conclusion:** This problem demonstrates a direct application of derivatives to find the rate of change of a geometric quantity. The key is to correctly differentiate the area formula and then substitute the given value of the radius.

ANSWER

(a) 6π\ \textcm^2/\textcm

(b) 8π\ \textcm^2/\textcm

## Question 2

### QUESTION

The volume of a cube is increasing at the rate of 8\ \textcm^3/\texts. How fast is the surface area increasing when the length of an edge is 12\text cm?

### SOLUTION

This question involves related rates, where we need to find the rate of change of the surface area of a cube given the rate of change of its volume.

**Step 1: Define variables and given rates**

Let be the volume of the cube, be the surface area, and be the length of an edge.

We are given that and we want to find when .

**Step 2: Write the formulas for volume and surface area**

The volume of a cube is .

The surface area of a cube is .

**Step 3: Differentiate both equations with respect to time**

Differentiating with respect to , we get:

Differentiating with respect to , we get:

**Step 4: Find using the given**

We know and , so we can plug these values into the equation :

**Step 5: Find using the value of**

Now we can plug and into the equation :

**Final Answer:** The surface area is increasing at a rate of .

### ANSWER

(8)/(3)\ \textcm^2/\texts

## Question 3

QUESTION

The radius of a circle is increasing uniformly at the rate of 3\ \textcm/\texts. Find the rate at which the area of the circle is increasing when the radius is 10\text cm.

SOLUTION

This question tests our understanding of related rates, specifically how the rate of change of the radius of a circle affects the rate of change of its area.

**Step 1: Identify the given information and what we need to find.**

We are given that the radius of the circle is increasing at a rate of . This can be written as:

We need to find the rate at which the area of the circle is increasing, which is , when the radius .

**Step 2: Write the formula for the area of a circle.**

The area of a circle with radius is given by:

**Step 3: Differentiate both sides of the area formula with respect to time .**

Using the chain rule, we differentiate both sides of the equation with respect to :

**Step 4: Substitute the given values.**

We are given that and . Substituting these values into the equation for , we get:

**Final Answer:** The rate at which the area of the circle is increasing when the radius is is .

ANSWER

60π\ \textcm^2/\texts

## Question 4

**QUESTION**

An edge of a variable cube is increasing at the rate of 3\ \textcm/\texts. How fast is the volume of the cube increasing when the edge is 10\text cm long?

**SOLUTION**

This question tests our understanding of related rates, specifically how the rate of change of a cube's edge affects the rate of change of its volume.

**Step 1: Define the variables**

Let be the length of an edge of the cube and be the volume of the cube.

**Step 2: Write the formula for the volume of a cube**

The volume of a cube is given by:

**Step 3: Differentiate both sides with respect to time**

We want to find , the rate of change of the volume with respect to time. Differentiating both sides of the volume equation with respect to , we get:

This uses the chain rule.

**Step 4: Substitute the given values**

We are given that and . Substituting these values into the equation for , we get:

**Step 5: State the final answer**

The volume of the cube is increasing at a rate of when the edge is long.

**ANSWER**

900\ \textcm^3/\texts

## Question 5

QUESTION

A stone is dropped into a quiet lake and waves move in circles at the speed of 5\ \textcm/\texts. At the instant when the radius of the circular wave is 8\text cm, how fast is the enclosed area increasing?

SOLUTION

This question involves related rates, where we need to find the rate of change of the area of a circle with respect to time, given the rate of change of its radius.

**Step 1: Identify the given information**

We are given that the radius of the circular wave is increasing at a rate of . This can be written as:

We are also given that at a particular instant, the radius is :

We need to find how fast the enclosed area is increasing, which means we need to find , where is the area of the circle.

**Step 2: Write the formula for the area of a circle**

The area of a circle is given by:

**Step 3: Differentiate the area formula with respect to time**

Using the chain rule, we differentiate both sides of the equation with respect to :

**Step 4: Substitute the given values**

We know that and . Substituting these values into the equation:

**Final Answer:**

The enclosed area is increasing at a rate of .

ANSWER

80π\ \textcm^2/\texts

## Question 6

### QUESTION

The radius of a circle is increasing at the rate of 0.7\ \textcm/\texts. What is the rate of increase of its circumference?

### SOLUTION

This question tests our understanding of related rates, specifically how the rate of change of a circle's radius affects the rate of change of its circumference.

**Step 1: Define the variables and given information**

Let be the radius of the circle and be its circumference. We are given that the rate of increase of the radius is . We need to find , the rate of increase of the circumference.

**Step 2: Write the formula for the circumference of a circle**

The circumference of a circle is given by the formula:

**Step 3: Differentiate both sides of the equation with respect to time**

We differentiate both sides of the equation with respect to time . Since is a constant, we have:

**Step 4: Substitute the given value of**

We are given that . Substituting this value into the equation, we get:

**Step 5: Simplify to find the rate of increase of the circumference**

Multiplying by , we get:

**Final Answer:** The rate of increase of the circumference is .

**Conclusion:** This problem demonstrates how to use related rates to find the rate of change of one quantity (circumference) given the rate of change of another quantity (radius). The key is to correctly differentiate the formula relating the two quantities with respect to time.

### ANSWER

1.4π\ \textcm/\texts

## Question 7

QUESTION

The length x of a rectangle is decreasing at the rate of 5\ \textcm/\textminute and the width y is increasing at the rate of 4\ \textcm/\textminute. When x = 8\text cm and y = 6\text cm, find the rates of change of

(a) the perimeter, and

(b) the area of the rectangle.

SOLUTION

This question involves finding the rate of change of the perimeter and area of a rectangle, given the rates of change of its length and width. It tests the application of derivatives in related rates problems.

**(a) Rate of change of the perimeter**

**Step 1: Write the formula for the perimeter**

The perimeter of a rectangle is given by:

, where is the length and is the width.

**Step 2: Differentiate with respect to time**

Differentiating both sides with respect to time , we get:

**Step 3: Substitute the given values**

We are given that (decreasing) and (increasing). Substituting these values, we get:

**Final Answer (a):** The rate of change of the perimeter is .

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**(b) Rate of change of the area**

**Step 1: Write the formula for the area**

The area of a rectangle is given by:

**Step 2: Differentiate with respect to time**

Differentiating both sides with respect to time , using the product rule, we get:

**Step 3: Substitute the given values**

We are given that , , , and . Substituting these values, we get:

**Final Answer (b):** The rate of change of the area is .

ANSWER

(a) -2\ \textcm/\textmin

(b) 2\ \textcm^2/\textmin

## Question 8

QUESTION

A balloon, which always remains spherical on inflation, is being inflated by pumping in 900 cubic centimetres of gas per second. Find the rate at which the radius of the balloon increases when the radius is 15\text cm.

SOLUTION

This question involves finding the rate of change of the radius of a spherical balloon with respect to time, given the rate at which its volume is increasing. This is an application of derivatives.

**Step 1: Identify the given information and what needs to be found.**

We are given that the volume of the balloon is increasing at a rate of cubic centimetres per second. This can be written as .

We need to find the rate at which the radius is increasing, which is , when .

**Step 2: Write the formula for the volume of a sphere.**

The volume of a sphere with radius is given by:

**Step 3: Differentiate the volume formula with respect to time .**

Differentiating both sides of the equation with respect to , we get:

Using the chain rule, we have:

**Step 4: Substitute the given values and solve for .**

We know that and . Substituting these values into the equation, we get:

**Step 5: State the final answer.**

The rate at which the radius of the balloon increases when the radius is is .

ANSWER

(1)/(π)\ \textcm/\texts

## Question 9

### QUESTION

A balloon, which always remains spherical has a variable radius. Find the rate at which its volume is increasing with the radius when the later is 10\text cm.

### SOLUTION

This question asks us to find the rate of change of the volume of a spherical balloon with respect to its radius, given that the radius is 10 cm. This involves applying the concept of derivatives to find related rates.

**Step 1: Write the formula for the volume of a sphere**

The volume of a sphere with radius is given by:

**Step 2: Differentiate the volume with respect to the radius**

We need to find , which represents the rate of change of volume with respect to the radius. Differentiating both sides of the volume formula with respect to , we get:

Using the power rule for differentiation, , we have:

**Step 3: Substitute the given radius value**

We are given that the radius cm. Substitute this value into the expression for :

**Step 4: State the final answer with correct units**

The rate at which the volume is increasing with respect to the radius when cm is cubic centimeters per centimeter.

**Final Answer:**

This method works because differentiation allows us to find the instantaneous rate of change of one variable with respect to another. In this case, we found how quickly the volume changes as the radius changes.

### ANSWER

400π\ \textcm^3/\textcm

## Question 10

### QUESTION

A ladder 5\text m long is leaning against a wall. The bottom of the ladder is pulled along the ground, away from the wall, at the rate of 2\text cm/\texts. How fast is its height on the wall decreasing when the foot of the ladder is 4\text m away from the wall?

### SOLUTION

This question involves related rates, where we need to find the rate of change of one quantity with respect to time, given the rate of change of another related quantity. We'll use the Pythagorean theorem to relate the distance of the ladder's foot from the wall and the ladder's height on the wall.

**Step 1: Define variables and given information**

Let be the distance of the foot of the ladder from the wall, and be the height of the ladder on the wall. We are given that the length of the ladder is 5 m, which is constant. We are also given that . We want to find when .

**Step 2: Establish the relationship between x and y**

By the Pythagorean theorem, we have:

**Step 3: Differentiate both sides with respect to time t**

Differentiating both sides of the equation with respect to , we get:

**Step 4: Find y when x = 4 m**

When , we can find using the Pythagorean theorem:

**Step 5: Substitute the known values into the differentiated equation and solve for dy/dt**

Substituting , , and into the differentiated equation, we get:

Converting to cm/s:

**Step 6: State the final answer**

The height of the ladder on the wall is decreasing at a rate of .

### ANSWER

(8)/(3)\ \textcm/\texts

## Question 11

### QUESTION

A particle moves along the curve 6y = x^3 + 2. Find the points on the curve at which the y-coordinate is changing 8 times as fast as the x-coordinate.

### SOLUTION

This question involves finding points on a curve where the rate of change of the -coordinate is a multiple of the rate of change of the -coordinate. This requires us to use derivatives to represent these rates of change.

**Step 1: Differentiate the given equation with respect to time**

We are given the equation . Differentiating both sides with respect to time , we get:

**Step 2: Use the given condition**

We are given that the -coordinate is changing 8 times as fast as the -coordinate. This means:

**Step 3: Substitute the given condition into the differentiated equation**

Substituting into , we get:

**Step 4: Solve for**

Assuming , we can divide both sides by :

Taking the square root of both sides, we get:

**Step 5: Find the corresponding values**

Substitute into the original equation :

So, one point is .

Substitute into the original equation :

So, the other point is .

**Final Answer:** The points are and .

### ANSWER

(4, 11) and (-4, -(31)/(3))

## Question 12

### QUESTION

The radius of an air bubble is increasing at the rate of (1)/(2)\ \textcm/\texts. At what rate is the volume of the bubble increasing when the radius is 1\text cm?

### SOLUTION

This question involves related rates, where we need to find the rate of change of the volume of a sphere (air bubble) with respect to time, given the rate of change of its radius.

**Step 1: Identify the given information and what needs to be found.**

We are given that the radius of the air bubble is increasing at a rate of . This can be written as:

We need to find the rate at which the volume of the bubble is increasing, i.e., , when the radius .

**Step 2: Write the formula for the volume of a sphere.**

The volume of a sphere with radius is given by:

**Step 3: Differentiate the volume formula with respect to time .**

Using the chain rule, we differentiate both sides of the equation with respect to :

**Step 4: Substitute the given values.**

We are given that and . Substituting these values into the equation for :

**Final Answer:**

The volume of the bubble is increasing at a rate of when the radius is .

### ANSWER

2π\ \textcm^3/\texts

## Question 13

QUESTION

A balloon, which always remains spherical, has a variable diameter (3)/(2)(2x+1). Find the rate of change of its volume with respect to x.

SOLUTION

This question asks us to find the rate of change of the volume of a spherical balloon with respect to , given that its diameter is a function of . This involves applying the chain rule of differentiation.

**Step 1: Find the radius of the balloon**

The diameter of the balloon is given as . The radius is half of the diameter.

**Step 2: Write the formula for the volume of a sphere**

The volume of a sphere with radius is given by:

**Step 3: Substitute the expression for into the volume formula**

Substituting into the volume formula, we get:

Simplifying, we have:

**Step 4: Differentiate with respect to**

We need to find . Using the chain rule:

Simplifying, we get:

**Final Answer:**

The rate of change of the volume with respect to is .

ANSWER

(27)/(8)π(2x+1)^2

## Question 14

### QUESTION

Sand is pouring from a pipe at the rate of 12\ \textcm^3/\texts. The falling sand forms a cone on the ground in such a way that the height of the cone is always one-sixth of the radius of the base. How fast is the height of the sand cone increasing when the height is 4\text cm?

### SOLUTION

This question involves related rates, specifically how the volume of a cone changes with respect to time and how that affects the height of the cone. We need to find the rate of change of the height when the height is 4 cm.

**Step 1: Identify given information and what to find**

We are given that sand is pouring at a rate of , which means , where is the volume of the cone and is time.

We are also given that the height of the cone is always one-sixth of the radius of the base, so or .

We need to find when .

**Step 2: Write the formula for the volume of a cone**

The volume of a cone is given by:

**Step 3: Substitute in terms of into the volume formula**

Since , we substitute this into the volume formula:

**Step 4: Differentiate both sides with respect to time**

Differentiating with respect to , we get:

**Step 5: Substitute the given value of and**

We know and we want to find when . Substituting these values, we get:

**Step 6: Solve for**

**Final Answer:**

The height of the sand cone is increasing at a rate of when the height is .

### ANSWER

(1)/(48π)\ \textcm/\texts

## Question 15

QUESTION

The total cost C(x) in Rupees associated with the production of x units of an item is given by

$C(x) = 0.007x^3 - 0.003x^2 + 15x + 4000$.

Find the marginal cost when 17 units are produced.

SOLUTION

This question tests the concept of marginal cost, which is the derivative of the total cost function with respect to the number of units produced.

**Step 1: Define Marginal Cost**

Marginal cost (MC) is the derivative of the total cost function with respect to the number of units . In other words, it represents the instantaneous rate of change of cost with respect to production.

**Step 2: Find the derivative of the cost function**

Given the cost function:

We differentiate with respect to :

Applying the power rule for differentiation:

**Step 3: Calculate the marginal cost when x = 17**

We need to find the marginal cost when 17 units are produced, so we substitute into the derivative:

**Final Answer:**

The marginal cost when 17 units are produced is ₹ 20.967.

ANSWER

₹ 20.967

## Question 16

QUESTION

The total revenue in Rupees received from the sale of x units of a product is given by

R(x) = 13x^2 + 26x + 15.

Find the marginal revenue when x = 7.

SOLUTION

This question tests the concept of marginal revenue, which is the derivative of the total revenue function. We need to find the derivative of the given revenue function and then evaluate it at .

**Step 1: Define the revenue function**

The total revenue function is given by:

**Step 2: Find the marginal revenue function**

Marginal revenue is the derivative of the total revenue function with respect to . We denote it as .

We differentiate with respect to :

Using the power rule of differentiation, , we get:

**Step 3: Evaluate the marginal revenue at**

We need to find . Substitute into the marginal revenue function:

**Final Answer:** The marginal revenue when is ₹ 208.

**Conclusion:** The marginal revenue represents the approximate change in revenue resulting from selling one additional unit. In this case, when 7 units are sold, the revenue from selling one more unit is approximately ₹ 208.

ANSWER

₹ 208

## Question 17

QUESTION

The rate of change of the area of a circle with respect to its radius r at r = 6\text cm is

(A) 10π

(B) 12π

(C) 8π

(D) 11π

SOLUTION

This question tests our understanding of the application of derivatives to find the rate of change of area with respect to the radius of a circle.

**Step 1: Recall the formula for the area of a circle**

The area of a circle with radius is given by:

**Step 2: Differentiate the area with respect to the radius**

We need to find the rate of change of the area with respect to the radius , which is given by the derivative .

Differentiating with respect to , we get:

Since is a constant, we have:

Using the power rule for differentiation, . Therefore:

**Step 3: Evaluate the derivative at cm**

We are asked to find the rate of change of the area at cm. So, we substitute into the expression for :

**Step 4: State the final answer**

The rate of change of the area of the circle with respect to its radius at cm is .

Therefore, the correct option is (B).

**Why other options are incorrect:**

(A) : This would be the answer if we incorrectly calculated the derivative or substituted the value of .

(C) : This is incorrect as the correct calculation yields .

(D) : This is also incorrect; the correct answer is .

**ANSWER**

B

## Question 18

QUESTION

The total revenue in Rupees received from the sale of x units of a product is given by

R(x) = 3x^2 + 36x + 5.

The marginal revenue, when x = 15 is

(A) 116

(B) 96

(C) 90

(D) 126

SOLUTION

This question tests the concept of marginal revenue, which is the derivative of the total revenue function with respect to the number of units sold.

**Step 1: Define Marginal Revenue**

Marginal revenue (MR) is the change in total revenue resulting from selling one additional unit of a product. Mathematically, it's the derivative of the total revenue function with respect to .

**Step 2: Find the derivative of the revenue function**

Given the total revenue function:

We need to find its derivative with respect to :

Using the power rule of differentiation, , and the fact that the derivative of a constant is zero:

So, the marginal revenue function is:

**Step 3: Calculate the marginal revenue when**

We need to find . Substitute into the marginal revenue function:

**Final Answer:** The marginal revenue when is 126.

Therefore, the correct option is (D) 126.

ANSWER

D

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## Key Formulas

### Important Formulas for Exercise 6.1: Rate of Change

| Formula / Concept | Description |
| --- | --- |
| Rate of Change | If a quantity y varies with respect to another quantity x such that $y = f(x)$, then the derivative $(dy)/(dx)$ (or $f'(x)$) represents the rate of change of y with respect to x. |
| Rate of Change with Respect to Time | The derivative $(dy)/(dt)$ represents the rate of change of a quantity y with respect to time t. This is a common application in physics and other sciences. |
| Related Rates (Using Chain Rule) | If two quantities, x and y, are functions of a third variable t (like time), and are related by an equation, their rates of change are connected by the chain rule: $(dy)/(dt) = (dy)/(dx) \cdot (dx)/(dt)$. |
| Marginal Cost | In economics, the marginal cost (MC) is the rate of change of the total cost (C) with respect to the number of units produced (x). It is given by $MC = (dC)/(dx)$. |
| Marginal Revenue | The marginal revenue (MR) is the rate of change of the total revenue (R) with respect to the number of units sold (x). It is given by $MR = (dR)/(dx)$. |
| **Common Geometric Formulas** | |
| Area of a Circle | $A = \pi r^2$ |
| Circumference of a Circle | $C = 2\pi r$ |
| Volume of a Cube | $V = x^3$, where x is the side length. |
| Surface Area of a Cube | $S = 6x^2$, where x is the side length. |
| Volume of a Sphere | $V = (4)/(3)\pi r^3$ |
| Surface Area of a Sphere | $S = 4\pi r^2$ |

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