CHAPTER-6

APPLICATION OF DERIVATIVES

01 MARK TYPE QUESTIONS

Q. NO	QUESTION	MARK
1.	The interval in which the function f given by $f(x) = x^2e^{-x}$ is strictly increasing (a) $(-\infty, \infty)$ (b) $(-\infty, 0)$ (c) $(2, \infty)$ (d) $(2, 0)$	1
2.	The maximum value of $(\frac{1}{x})^x$ (a) e (b) e^e (c) $e^{\frac{1}{e}}$ (d) $(\frac{1}{e})^{\frac{1}{e}}$	1
3.	The maximum value of $[x(x-1) + 1]^{1/3}, 0 \leq x \leq 1$ is (a) $(\frac{1}{3})^{1/3}$ (b) $\frac{1}{2}$ (c) 1 (d) 0	1
4.	The maximum volume of slope of the curve $y= -x^3+3x^2+12x-5$ is (a) 0 (b) 9 (c) 12 (d) 15	1
5.	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) 126 (b) 96 (c) 90 (d) 116	1
6.	The rate of change of the area of a circle with respect to its radius r at r = 6 cm is (a) 10π (b) 12π (c) 8π (d) 11π	1
7.	The rate of change in area of square w.r.t side when side is $\frac{1}{\sqrt{3}}$ unit is (a) $\frac{2}{\sqrt{3}}$ unit^2/sec (b) $\frac{1}{\sqrt{53}}$ unit^2/sec (c) 2 unit^2/sec (d) none of these	1
8.	For which value of 'a' is the function $f(x) = ax^2+2$ decreasing in [1.2] ? (a) $(1, 2)$ (b) $(-\infty, 0)$ (c) [1, 2] (d) none of these	1
9.	If the function $f(x) = 2x^2 – kx +5$ is increasing on [1,2] ,then k lies in the interval (a) $(-\infty, 4)$ (b) $(4,\infty)$ (c) $(-\infty, 8)$ (d) $(8,\infty)$	1
10.	If x is real,the minimum value of $x^2-8x+17$ is (a) -1 (b) 0 (c) 1 (d) 2	1
11.	The rate of change of the area of a wheel of a cycle with respect to the distance between the outer surface and the hub of the wheel, which is 6 cm is (a)36π (c)12 π (b)24 π (d)17 π 	1

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12.	Find the maximum value of the function $f(x) = 3x^2 - 12x + 5$ within the interval $[-1,4]$.	1
13.	There is a bottle company say C whose total revenue in rupees received from the sale of x units of bottle is given by $R(x) = 5x^3 + 3x + 2$. When 12 units of the bottle will be sold then find the marginal revenue.  	1
14.	The value of x for which $(x - x^2)$ is maximum is (a)3/4 (c)1/3 (b)1/2 (d)1/4	1
15.	If x is real, then the minimum value of $x^2 - 8x + 17$ is (a)-1 (c)0 (b)1 (d)2	1
16.	The value of b for which the function $f(x) = x + cos\ cos\ x + b$ is strictly decreasing over R is (a)b≥1 (c)for no values of b (b)b≤1 (d)b=1	1
17.	The interval on which the function $f(x) = x^2 - 4x + 6$ is strictly increasing is (a) $(-\infty, 2) \cup (2, \infty)$ (b) $(2, \infty)$ (c) $(-\infty, 2)$ (d) $(-\infty, 2] \cup (2, \infty)$	1
18.	The area of a trapezium is defined by a function which is given by $f(x) = (10 + x)\sqrt{100 - x^2}$ then the area when it is maximized is (a)75 cm^2 (c)$7\sqrt{3}$ cm^2 (b)$75\sqrt{3}$ cm^2 (d)5 cm^2	1
19.	A particle is moving along the x-axis with a velocity given by $v(t) = 3t^2 - 4t + 1$. Find the acceleration of the particle when $t = 2$.	1
20.	The cost C of producing x units of a product is given by $C(x) = 1000 + 5x + 0.02x^2$. Find the production level that minimizes the cost.	1
21.	Sahaj wants to prepare a handmade gift for his father's birthday at Home. For making lower part of box, he takes a square piece of Cardboard of side 20cm.If x cm be the length of each side of the Square cardboard which is to be cut from corners from square piece of side 20 cm then What is the volume function of open box formed by folding up the cutting corners?	1
22.	A particle is moving along the curve represented by the polynomial f(x) $=(x-2)^2(x-1)$. Based on above information answer the following questions: Find the rate at which the particle is moving.	1

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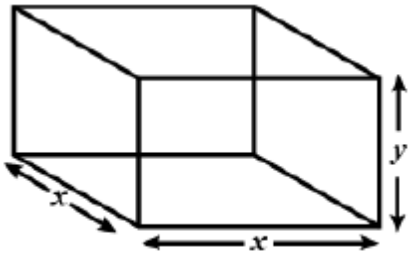
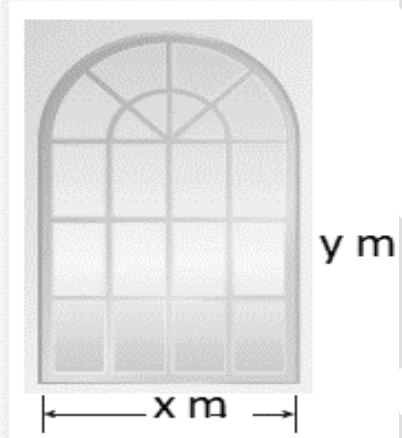
23.	1. Read the following passage and answer the questions given below Anuja wants to make a project for State level Science Exhibition. For this she wants to make metal box with square base and vertical sides to contain of 1024 cm^3 water material for top and bottom costs ₹ 5 per cm^2 and material for slides costs ₹2.5 per cm^2.  What is the cost of the box in terms of x?	1
24.	Dr. Rohan residing in Delhi went to see an apartment of 3BHK in Noida. The window of the house in the form of a rectangle surrounded by a semicircular opening having a perimeter of the window 10 m as shown in the figure  (i) If x and y represents the length and breadth of the rectangular region, then what is the relation between the variables.	1
25.	Read the following passage and the answer the questions given below. f (x)= -- $0.1x^2$ + m x + 98.6 , $0 \leq x \leq 12$, m being a constant, where f (x) is the temperature in ^{0} F at x days. Find the intervals in which the function is strictly increasing / strictly decreasing	1
26.	A company makes closed water storage tank. The water tank is cylindrical in shape. Let S be the given surface area ,r be the radius of base and h be height of the tank . Based on the information provided answer the following : Relation between S,r and h is: (a) $S = 2\pi rh + 2\pi r^2$	1

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	(b) $S = 2\pi rh + \pi r^2$ (c) $S = \pi r^2 h + \pi r^2$ (d) $S = \pi r^2 h + 2\pi r^2$	
27.	Questions consists of two statements−Assertion (A) and Reason (R). Answer these questions selecting the appropriate option given below – a) Both A and R are true and R is the correct explanation for A b) Both A and R are true and R is not the correct explanation for A c) A is true but R is false d) A is false but R is true Assertion (A : The function $f(x) = x^3 + 3x^2 + 3x + 7$ is increasing for all real values of x Reason (R) : For any function $y = f(x)$ to be increasing, $\frac{dy}{dx} > 0$	1
28.	Function $f(x) = 2x^3 - 6x + 5$, is an increasing function in the interval (A) $\left(-\infty, -\frac{1}{2}\right) \cup (\frac{1}{2}, \infty)$ (B) $(-1,1)$ (C) $\left(-1, -\frac{1}{2}\right)$ (D) $(-\infty, -1) \cup (1, \infty)$	1
29.	The area of a trapezium is defined by function f and given by $f(x) = (10 + x)\sqrt{100 - x^2}$, then the area when it is maximised is: (A) 75 sq. unit (B) $7\sqrt{3}$ sq. unit (C) $75\sqrt{3}$ sq. unit (D) 5 sq. unit	1
30.	The maximum value of $[x(x - 1) + 1]^{\frac{1}{3}}, 0 \leq x \leq 1$ is: (A) 0 (B) $\frac{1}{2}$ (C) 1 (D) $\sqrt[3]{\frac{1}{3}}$	1

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ANSWERS:

Q. NO	ANSWER	MARKS
1.	(d) $(2, 0)$	1
2.	(c) $e^{\frac{1}{e}}$	1
3.	(c) 1	1
4.	(d) 15	1
5.	(a) 126	1
6.	(b) 12π	1
7.	(a) $\frac{2}{\sqrt{3}}$ unit^2/sec	1
8.	(b) $(-\infty, 0)$	1
9.	(a) $(-\infty, 4)$	1
10.	(c) 1	1
11.	c	1
12.	To find the maximum value of a function within a given interval, we need to follow these steps: Calculate the derivative of $f(x)$: $f'(x)=6x-12$ Set $f'(x)=0$ and solve for x: $6x-12=0$ $x=2$ **Now** Determine the endpoints of the interval. The interval is $[-1, 4]$, so the endpoints are $x=-1$ and $x=4$. **Step 3:** Evaluate the function $f(x)$ at the critical points and endpoints. Evaluate $f(x)$ at the critical point $x=2$: $f(2)=3(2)^2-12(2)+5=12-24+5=-7$. Evaluate $f(x)$ at the endpoints $x=-1$ and $x=4$: $f(-1)=3(-1)^2-12(-1)+5=3+12+5=20$ $f(4)=3(4)^2-12(4)+5=48-48+5=5$. Compare the values obtained in Step 3 to determine the maximum value. The maximum value of the function within the interval $[-1, 4]$ is 2020, which occurs at $x=-1$. Therefore, the maximum value of $f(x)=3x^2-12x+5$ within the interval $[-1,4]$ is 20.	1
13.	Marginal revenue is rate of change of total revenue. As total revenue is given as $R(x) = 5x^3 + 3x + 2$ So marginal revenue is $\frac{dR}{dx}= 15x^2 + 3$ At $x = 12$ $\frac{dR}{dx}\|_{x=12}= 15(12)^2 + 3=2163$	1
14.	b	1
15.	b	1
16.	c	1
17.	b	1
18.	b	1
19.	Given $v(t) =3t^2-4t+1$, we want to find $a(t)$ when $t=2$. Acceleration is the derivative of velocity with respect to time: $a(t)=dv/dt$. Differentiate $v(t)$ with respect to t: $a(t)=d/dt(3t2-4t+1)$.	1

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	$a(t)=6t-4$. Evaluate $a(t)$ at $t=2$: $a(2)=6(2)-4$. $a(2)=12-4=8$ m/s². So, the acceleration of the particle when $t=2$ is 88 m/s².	
20.	Given $C=1000+5x+0.02x^2$, we want to find the value of x that minimizes C. Differentiate C with respect to x: $dC/dx=5+0.04x$. Set $dC/dx=0$ and solve for x. So, $5+0.04x=0$ Or $0.04x=-5$ Or $x=-5/0.045=-125$. Since the number of units produced cannot be negative, we reject the negative value. So, the production level that minimizes the cost is $x=0$ units.	1
21.	$V=x(20-2x)(20-2x)$	1
22.	$f'(x)=(x-2)(3x-4)$.	1
23.	Let C denotes the cost of the box $C=2x^2\times 5+4xy\times 2.5$ $\Longrightarrow C=10x^2+\frac{10240}{x}$	1
24.	$X+2y+\pi\frac{x}{2}=10$	1
25.	f (x)= -- $0.1x^2$ + m x + 98.6 $f'(x)) = -0.2x + 1.2 = -0.2(x-6)$ In the Interval [0, 6) $f'(x)$)+ve then f is strictly increasing in [0, 6) In the Interval (6, 12] $f'(x)$ is -ve f is strictly decreasing in (6, 12]	1
26.	a	1
27.	a	1
28.	d	1
29.	c	1
30.	c	1

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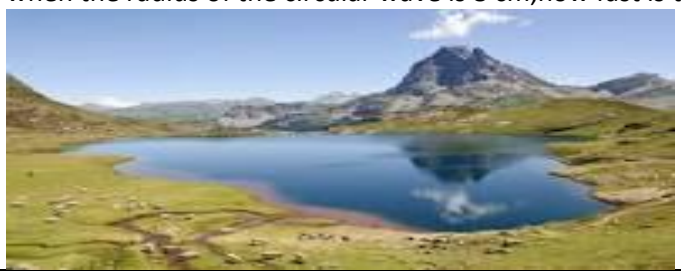
APPLICATION OF DERIVATIVES

02 MARK TYPE QUESTIONS

Q. NO	QUESTION	MARK
1.	A stone is dropped into a quiet lake and waves move in circles at the speed of 5 cm/s. At the instant when the radius of the circular wave is 8 cm,how fast is the enclosed area increasing ? 	2
2.	The volume of a cube is increasing at the rate of 9 cm^3/s.How fast is its surface area increasing when the length of an edge is 10 cm? 	2
3.	Find the values of x for which $y = [x(x-2)]^2$ is an increasing function.	2
4.	The money to be spent for the welfare of the employees of a firm is proportional to the rate of change of its total revenue(marginal revenue).If the total revenue(in rupees) received from the sale of x units of a product is given by $R(x)=3x^2+36x+5$,find the marginal revenue when x=5. 	2
5.	Prove that the function f given by f(x) = log sinx is strictly increasing on $(0, \frac{\pi}{2})$ and strictly decreasing on $(\frac{\pi}{2},)$.	2
6.	A car is moving along a straight road. Its position at a time t is given by $s(t) = 2t^3 - 3t^2 - 12t + 1$ meters. At what time when the car changes direction? (a)30 seconds (c)1 seconds (b)2 seconds (d) 22 seconds 	2
7.	A spherical snowball is melting in such a way that its radius decreasing at a rate of 0.1 cm/min. At	2

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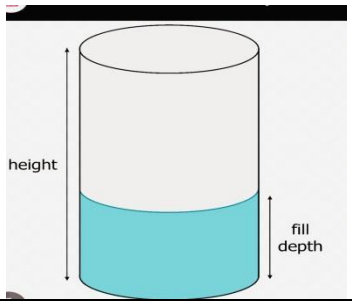
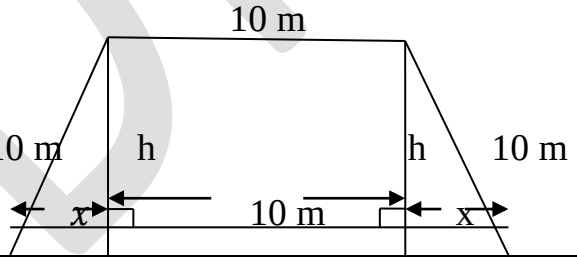
	what rate is the volume of the snowball is decreasing when the radius is 5 cm?	
8.	A cylindrical tank is being filled with water at a constant rate. The tank has a height of 6m and radius of 4m. If the water level rises at a rate of 2m per hour, how fast is the volume of water increasing when the water level is 3m high?  	2
9.	A stone is dropped into a calm lake, creating a circular ripple that expands at a rate of 1.5m/s. Find the rate at which the area of the ripple is increasing when the radius is 4m.	2
10.	The side length of a square is increasing at a rate of 2cm/s. At what rate is the area of the square increasing when the side length is 5cm?	2
11.	**Assertion** (A) : The function $y = \log(1+x) - \frac{2x}{2+x}$ is decreasing throughout its domain. **Reason (R)** :The domain of the function $y = \log(1+x) - \frac{2x}{2+x}$ is (- 1, ∞). 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. E.Both A and R are false.	2
12.	The front gate of a building is in the shape of a trapezium as shown below. Its three sides other than base are of 10 m each. The height of the gate is h meter. On the basis of above figure, answer the following questions:  	2

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	  (i) Find the Area (A) of the gate expressed as a function of x . (ii) Find the value of x when Area (A) is maximum (iii) Find the Maximum value of Area (A)	
13.	Read the following passage and the answer the questions given below. The temperature of a person during an intestinal illness is given by f (x)= -- $0.1x^2$ + m x + 98.6 , $0 \leq x \leq 12$, m being a constant, where f (x) is the temperature in ^{0} F at x days. **(i)** is the function differentiable in the interval (0,12) ? Justify your answer. **(ii)** If 6 is the critical point of the function, then find the value of the constant m.	2
14.	Sahaj wants to prepare a handmade gift for his father's birthday at Home.For making lower part of box,he takes a square piece of Cardboard of side 20cm.If x cm be the length of each side of the Square cardboard which is to be cut from corners from square pieceof side 20 cm then Sahaj is interested in maximising the volume of the box. So what should be the value of x to be cut off so that volume of box is maximum?	2
15.	A particle is moving along the curve represented by the polynomial f(x) =$(x-2)^2(x-1)$. Based on above information answer the following questions: Find the interval where f(x) is strictly increasing.	2

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ANSWERS:

Q. NO	ANSWER	MARKS
1.	Let x be the radius and A be the area of circle $\frac{dx}{dt}$ = 5 cm/s A = πr^2 $\frac{dA}{dt}$ =$2\pi r \frac{dx}{dt}$ = 2π x 8 x 5 = 80πcm^2/s	2
2.	Let V be the volume and S be the surface area of cube of side x cm. $\frac{dV}{dt}$ = 9 cm^3/s V = x^3 $\frac{dV}{dt}$ = 3x^2. $\frac{dx}{dt}$ $\frac{dx}{dt} = \frac{3}{x^2}$ Again S = 6x^2 $\frac{dS}{dt}$ =12x . $\frac{3}{x^2}$ = 36/x = 36/10 = 3.6 cm^2/s	2
3.	Y=[x(x-2)]^2 $\frac{dy}{dx}$ = 2[x(x-2)] x (2x-2) = 4x(x-1)(x-2) , critical points x=0/1/2 For increasing function $\frac{dy}{dx} > 0$ From sign rule y increasing for xϵ (0,1) $\cup$ (2,∞)	2
4.	R(x)=3x^2+36x+5 $\frac{dR}{dx}$ = 6x +36 $\frac{dR}{dx}$ at x= 5 is 66	2
5.	f'(x) = $\frac{1}{sinx}$. cosx = cotx When x ϵ (0, $\frac{\pi}{2}$) then f'(x) > 0 and when x ϵ ($\frac{\pi}{2}$, π) then f'(x) < 0 So, f(x) is strictly increasing on (0, $\frac{\pi}{2}$) and strictly decreasing on ($\frac{\pi}{2}$,).	2
6.	Given, position of a car at time t is given as $s(t) = 2t^3 - 3t^2 - 12t + 1$ A car changes direction when its velocity changes its sign. So the velocity is the derivative of the position at time t. i.e. $v(t)$=$s'(t)$ So in order to know when the velocity changes we have to set $v(t) = 0$. $6t^2 - 6t - 12$=0 Or $t^2 - t - 2$=0 Or $(t-2)(t+1) = 0$ So, $t = 2$ *or* $t = -1$ As time can't be negative so the car changes its direction at 2 seconds.	2
7.	There is a snowball of spherical shape. Let its radius be r . Then the volume of the snowball is same as the volume of the sphere with radius r. The volume of the sphere is $v = \frac{4}{3}\pi r^3$ Now $\frac{dv}{dt} = 4\pi r^2 \frac{dr}{dt}$ Since the radius is decreasing so $\frac{dr}{dt} = -0.1$ cm/min and radius is 5cm so $\frac{dv}{dt} = 4\pi(5)^2(-0.1) = -10\pi$ cm^3/min. So the volume of the snowball is decreasing at a rate of 10π cm^3/min.	2
8.	If r is the radius of the cylindrical tank and its height is h then volume of the cylindrical tank will be	2

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	$v = \pi r^2 h$ Given that $\frac{dh}{dt}$= 2 m/hr , h = 3m and r = 4m Now $\frac{dv}{dt} = 2\pi rh\frac{dv}{dt} + \pi r^2\frac{dh}{dt}$ $\frac{dv}{dt} = 2\pi(4)(3)(0) + \pi(4)^2(2)$ =32π m3/hr The volume of water is increasing at a rate of 32πcubic meters per hour.	
9.	Let *r* be the radius of the circular ripple and *A* be the area of the ripple. The area *A* of a circle is $A=\pi r^2$ Differentiate *A* with respect to time *t*: $\frac{dA}{dt}=2\pi r\frac{dr}{dt}$ Given $\frac{dr}{dt}$=1.5m/s and *r*=4m, substitute and solve for $\frac{dA}{dt}$: $\frac{dA}{dt}=2\pi(4)\cdot1.5=12\pi m^2/s$ So, when the radius of the ripple is 4 m4m, the area of the ripple is increasing at a rate of$12\pi m^2/s$.	2
10.	Let *s* be the side length of the square and *A* be the area of the square. The area *A* of a square is $A=s^2$ Differentiate *A* with respect to time *t*: $\frac{dA}{dt}=2s\frac{ds}{dt}$ Given $\frac{ds}{dt}$=2cm/s and *s*=5cm, substitute and solve for $\frac{dA}{dt}$: $\frac{dA}{dt}=2(5)\cdot2=20cm^2/s$ So, when the side length of the square is 5cm, the area of the square is increasing at a rate of 20cm2/s.	2
11.	d	2
12.	**(i)** $(10+x)\sqrt{100-x^2}$ **(ii)** $5\sqrt{3}$ m $(iii)\frac{75\sqrt{3}}{2}$ m^2	2
13.	(i) f (x)= -- 0.1x ^{2} + m x + 98.6 being a polynomial function, is differentiable everywhere, hence, differentiable in (0, 12) (ii) $f'(x)) = -0.2x + m$ Since, 6 is the critical point, $f'(x) = 0 \Longrightarrow m = 1.2$	2
14.	for x= $\frac{10}{3}$,volume is maximum	2
15.	f(x) is strictly inc in (-∞,4/3)∪ [2, ∞)	2

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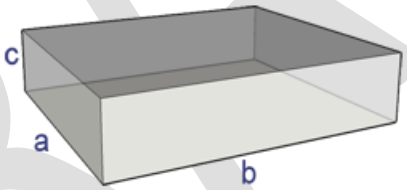
APPLICATION OF DERIVATIVES

03 MARK TYPE QUESTIONS

Q. NO	QUESTION	MARK
1.	Sand is pouring from a pipe at the rate of 12 cm^3/s.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 cm ? 	3
2.	Prove that y = $\frac{4sin\theta}{(2+cos\theta)} - \theta$ is increasing function of θ in [0,$\frac{\pi}{2}$].	3
3.	A rectangular sheet of tin 45 cm by 24 cm is to be made into a box without top,by cutting off square from each corner and folding up the flaps.What should be the side of the square to be cut off so that the  volume of the box is maximum ?	3
4.	A wire is 12 meters long. If the wire is cut into two pieces and each piece is bent to form a square, find the lengths of the sides of the squares to maximize the total area.	3
5.	A kite is flying at a height of 50m above the ground. The kite string is attached to a point on the ground 100m away from the person flying the kite. The string is being let out at a rate of 2m/s. How fast is the kite rising when it is 150m away from the person? 	3
6.	A rocket is fired vertically upwards. It ascends with a velocity given by $v=50t-5t^2$, where t is the time in seconds and v is the velocity in m/s. Find the maximum height reached by the rocket and the time at which it occurs.	3

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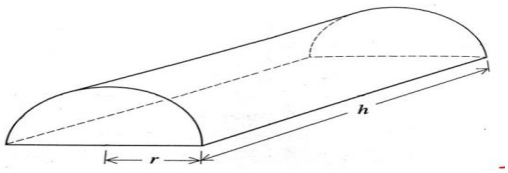
7.	Read the following passage and answer the questions given below. In a street two lamp posts are 300 feet apart. The light intensity at a distance d from the first (stronger) lamp post is $\frac{1000}{d^2}$, the light intensity at distance d from the second (weaker) lamp post is $\frac{125}{d^2}$ (in both cases the light intensity is inversely proportional to the square of the distance to the light source).  The combined light intensity is the sum of the two light intensities coming from both lamp posts. Find the distance of the darkest spot between the two lights ?	3
8.	Read the following passage and answer the questions given below: Some young entrepreneurs started an industry “Young achievers” for casting metal into various shapes. They put up an advertisement online stating the same and expecting order to cast method for toys, sculptures, decorative pieces and more. A group of friends wanted to make innovative toys and hence contacted the “Young achievers” to order them to cast metal into solid half cylinders with a rectangular base and semi circular ends.  (i)For the given volume V, Find the condition for the total surface area S to be minimum. (ii) Use second derivative test to prove that Surface area is minimum for given volume.	3

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	OR (ii) Find the ratio h: 2r for S to be minimum.	
9.	Find the intervals in which the function f given by $f(x) = sinx + cosx$, Where $0 \leq x \leq 2\pi$, is strictly increasing or strictly decreasing.	3

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ANSWERS:

Q. NO	ANSWER	MARKS
1.	$V = \frac{1}{3}\pi r^2 h$, Given $\frac{dV}{dt}$ = 12 cm^3/s Or, $\frac{d}{dt}(\frac{1}{3}\pi r^2 h) = 12$ Or,r = 6h Now $\frac{d}{dt}(\frac{1}{3}\pi(6h)^2 h) = 12$ Or, $\frac{dh}{dt} = 1/3\pi h^2$ When h= 4 cm, $\frac{dh}{dt} = 1/48\pi$.	3
2.	$y = \frac{4sin\theta}{(2+cos\theta)} - \theta$ $\frac{dy}{dx} = \frac{(2+cos\theta).4cos\theta - 4\ sin\theta.(\theta - sin\theta)}{(2+cos\theta)^2} - 1 = \frac{cos\theta.(4-cos\theta)}{(2+cos\theta)^2}$ $\frac{dy}{dx} > 0$ for $\theta \in [\ 0, \frac{\pi}{2}\ ]$ i.e increasing function in $[\ 0, \frac{\pi}{2}\ ]$.	3
3.	Let x be the length of square V = (45-2x)(24-2x).x $\frac{dV}{dx} = 12x^2 - 276x + 1080 = 12(x-18)(x-5)$ For maximum $\frac{dV}{dx}$ = 0, x = 5,18 X = 18 is not possible as breadth is 24 cm. $\frac{d^2V}{dx^2}$ at x = 5 is - 156 $<$ 0(x = 5 is the point of maximum).	3
4.	Let *x* be the length of one piece of wire, so the length of the other piece is 12−*x*. Each piece is bent into a square, so the sides of each square are $s=\frac{x}{4}$. The total area *A* of the two squares is $A=2s^2$. Substitute $s=4x$ into the area equation: $A=2(\frac{x}{4})^2=\frac{x^2}{8}$ Differentiate *A* with respect to *x*, set the derivative to 0, and solve for *x*: $\frac{dA}{dx}=\frac{2x}{8}=\frac{x}{4}$ Setting $\frac{dA}{dx}=0$: $\frac{x}{4}=0$, which has no solution. So, there are no critical points for *A* and no maximum or minimum. Since the wire is 12 meters long, we must have *x*+(12−*x*)=12, which means *x*=6. The lengths of the sides of the squares are $s=\frac{x}{4}=\frac{6}{4}=\frac{3}{2}$ meters.	3
5.	Let *x* be the horizontal distance from the person to the point directly below the kite, and let *h* be the height of the kite above the ground. Given *h*=50m, $\frac{dx}{dt}$=2m/s, and *x*=100m, we want to find $\frac{dh}{dt}$ when *x*=150m. By the Pythagorean theorem, $x^2+h^2=d^2$, where *d* is the length of the kite string. Since the string is being let out at a constant rate, $\frac{dx}{dt}$=2m/s. Differentiate both sides of the equation with respect to time *t*: $2x\frac{dx}{dt}+2h\frac{dh}{dt}=2\frac{dd}{dt}$ Substitute the given values: $2(100)(2)+2(50)\frac{dh}{dt}=2(2)$ $400+100\frac{dh}{dt}=4$ Solve for $\frac{dh}{dt}$:	3

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	$100\frac{dh}{dt}=4-400$ $100\frac{dh}{dt}=-396$ $\frac{dh}{dt}=-396/100$ $\frac{dh}{dt}=-3.96$m/s So, when the kite is 150m away from the person, the kite is rising at a rate of 3.96m/s downwards .	
6.	Given the velocity function $v=50t-5t2$, we want to find the maximum height reached by the rocket and the time at which it occurs. The height h of the rocket can be determined by integrating the velocity function: $h=\int v\,dt=\int (50t-5t^2)\,dt$ $h=25t^2-\frac{5}{3}t^3+C$ To find the constant C, we can use the initial condition that at $t=0$, $h=0$ $0=25(0)^2-\frac{5}{3}(0)^3+C$ $C=0$ So, the height function is $h=25t^2-\frac{5}{3}t^3$ To find the maximum height, we need to find the critical points of h by differentiating with respect to t and setting the derivative equal to 0: $\frac{dh}{dt}=50t-5t^2$ Setting $\frac{dh}{dt}=0$: $0=50t-5t2$ $0=t(50-5t)$ This gives $t=0$ and $t=10$ as critical points. Evaluate the height at these critical points: $h(0)=25(0)^2-\frac{5}{3}(0)^3=0$ $h(10)=25(10)^2-\frac{5}{3}(10)^3=2500-\frac{5000}{3}=\frac{500}{3}$m So, the rocket reaches a maximum height of $\frac{500}{3}$ m at $t=10$ seconds.	3
7.	) We have I(x) = $\frac{1000}{x^2}+\frac{125}{(300-x)^2}$ I'(x) = $\frac{-2000}{x^3}+\frac{250}{(300-x)^3}$ I'(x) = $\frac{-6000}{x^4}+\frac{750}{(300-x)^4}$ For maxima / minima, I'(x) =0 $\frac{-2000}{x^3}+\frac{250}{(300-x)^3}=0\Rightarrow\frac{2000}{x^3}=\frac{250}{(300-x)^3}\Rightarrow 8(300-x)^3=x^3$ Taking cube root on both sides, we get $2(300-x)=x\Rightarrow x=200$ Thus I(x) is minimum when you are at 200 feet from the strong intensity lamp post. Since, I(x) is minimum when x = 200 feet, therefore the darkest spot between the two light is at a distance of 200	3

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	feet from stronger lamp post, i.e., at a distance of 300 – 200 = 100 feet from the weaker lamp post.	
8.	(i) $\frac{dS}{dr}=2\pi r-\frac{2V(\pi+2)}{\pi r^2}$ $For\ \min\ \frac{dS}{dr}=0\Rightarrow\pi^2r^3=V(\pi+2)$ (ii) $\frac{dS}{dr}=2\pi r-\frac{2V(\pi+2)}{\pi r^2}$ $\frac{d^2S}{dr^2}=2\pi+\frac{4V(\pi+2)}{\pi}.\frac{1}{r^3}$ $=2\pi+\frac{4\pi^2r^3}{\pi r^3}=6\pi>0$ OR Since $\pi^2r^3=V(\pi+2)$ $\Rightarrow\ \pi^2r^3=\frac{1}{2}\pi r^2h(\pi+2)$ $\Rightarrow h:2r=\pi:\pi+2$	3
9.	[0, π/4),(π/4, 5π/4) and(5 π/4, 2π] checking in each intervals, for Strictly increasing & Strictly decreasing	3

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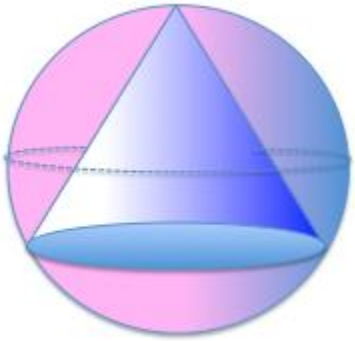
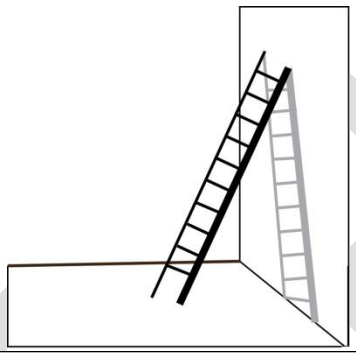
CHAPTER-6

APPLICATION OF DERIVATIVES

04 MARK TYPE QUESTIONS

Q. NO	QUESTION	MARK
1.	Prove that the volume of the largest cone that can be inscribed in a sphere of radius 'a'  is $\frac{8}{27}$ of the volume of the sphere.	4
2.	Find the intervals in which the function $f(x) = \frac{3}{2}x^4 - 4x^3 - 45x^2 + 51$ is (a) strictly increasing (b) strictly decreasing	4
3.	Find the equation of the tangent line to the curve $y=x^3-4x$ at the point where $x=2$.	4
4.	A ladder 12 meters long is leaning against a wall. The bottom of the ladder is sliding away from the wall at a rate of 2 m/s. How fast is the top of the ladder sliding down the wall when the bottom of the ladder is 5 meters from the wall? 	4
5.	The Relation between the height of the plant (y in cm) with respect to exposure to sunlight is governed by the following equation $y = 4x - \frac{1}{2}x^2$ where x is the number of days exposed to sunlight.  (i) What is the rate of growth of plant? (1 mark) (ii) On which day the plant attain the maximum height. (1 mark) (iii) What is the maximum height of the plant? (2 mark) **OR** What is the height of the plant after two days? (2 mark)	4
6.	A real estate company is going to build a new apartment complex. The land	4

	they have purchased can hold at most 5000 apartments. Also, if they make x apartments, then the maintenance costs for the building, landscaping etc., would be as follows: Fixed cost = Rs 40,00,000 Variable cost =Rs $(140x - 0.04x^2)$  If C(x) denote the maintenance cost function, then $C(x) = 40,00,000 + 140x - 0.04x^2$ (i) Find the intervals in which the function C(x) is strictly increasing/strictly decreasing. (ii) Find the points of local maximum/local minimum, if any, in the interval (0, 5000) as well as the points of absolute maximum/absolute minimum in the interval [0, 5000]. Also, find the corresponding local maximum/local minimum and the absolute maximum/absolute minimum values of the function.	

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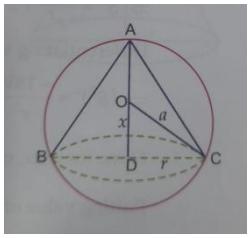
ANSWERS:

Q. NO	ANSWER	MARKS
1.	Let OD = x and DC = r and height = h h= AD = AO +OD = a+x……..(1)  in Δ ODC $a^2 = r^2+x^2$……..(2) volume of cone V = $\frac{1}{3}\pi r^2 h$, V(x) = $\frac{1}{3}\pi(a^2-x^2)(a+x)$ V'(x) = $\frac{1}{3}\pi(a-3x)(a+x)$ V''(x) = $\frac{1}{3}\pi[(a+x)(-3)+(a-3x)(1)]$ For maximum/minimum value V'(x) = 0 X = -a or x = $\frac{a}{3}$ Neglecting x = -a So, volume is maximum when x = $\frac{a}{3}$. Putting x = $\frac{a}{3}$ in equ^n(1) and (2) h = $\frac{4a}{3}$ and r^2 = $\frac{8a^2}{9}$ Volume of cone = $\frac{8}{27}(\frac{4}{3}\pi a^3)$ Volume of cone = $\frac{8}{27}$ (volume of sphere).	4
2.	$f(x) = \frac{3}{2}x^4 - 4x^3 - 45x^2 + 51$ $f'(x) = 6x^3-12x^2-90x = 6x(x+3)(x-5)$ critical pts x = 0/-3/5 (a)f(x) is strictly increasing in $(-3,0) \cup (5,\infty)$ (b)f(x) is strictly decreasing in $(-\infty,-3) \cup (0,5)$.	4
3.	The slope of the tangent line is the derivative of the function evaluated at the given point. Given the function $y=x^3-4x$, its derivative is $\frac{dy}{dx}=3x^2-4$. Evaluate the derivative at $x=2$ so $\frac{dy}{dx}=3(2)^2-4=8$. The point of tangency is $(2,y(2))=(2,4)$. The equation of a line with slope m passing through point (x_1,y_1) is given by: $y-y_1= m(x-x_1)$. Substitute $m=8$ and $(x_1,y_1)=(2,4)$: $y-4=8(x-2)$ Simplify and write in slope-intercept form: $y=8x-12$ So, the equation of the tangent line is $y=8x-12$.	4
4.	Let x be the distance between the bottom of the ladder and the wall, and let y be the height of the ladder on the wall. Given $\frac{dx}{dt}$=2 m/s and x=5 m, we want to find $\frac{dy}{dt}$ By the Pythagorean theorem, $x^2+y^2=122$, so $y^2= \sqrt{144 - x^2}$ Differentiate both sides with respect to time t: $2y\frac{dy}{dt}=-2x\frac{dx}{dt}$	4

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	Solve for $\frac{dy}{dt}$: $\frac{dy}{dt}=-\frac{x}{y}\frac{dx}{dt}$ Substitute *x*=5 and *y*= $\sqrt{144-x^2}$ $\frac{dy}{dt}=\frac{-5}{\sqrt{144-5^2}}\cdot 2$ $\frac{dy}{dt}=-\frac{10}{\sqrt{119}}$ m/s. So, when the bottom of the ladder is 55 meters from the wall, the top of the ladder is sliding down the wall at a rate of $-\frac{10}{\sqrt{119}}$m/s.	
5.	(i) As the height of the plant is given by $y = 4x - \frac{1}{2}x^2$ The rate of growth of plant is given by differentiating the above equation w.r.t x $$y'(x) = 4 - x$$ (ii) Maximum value of the given equation is $y'(x) = 0 \Longrightarrow x = 4$ So, the maximum height of the plant is on day x=4, (iii) $y(4) = 4 \times 4 - \frac{1}{2}4^2 = 8$ So, maximum height of plant is 8 cm. OR The height of the plant after x=2 days is $\mathbf{y(2) = 4 \times 2 - \frac{1}{2}2^2 = 6}$ So, after two days height of the plant is 6 cm.	4
6.	**(i)** We have C(x) = 40,00,000 + 140x – 0.04x^2 $\therefore$ C'(x) = 140 – 0.08x For finding critical points,put C'(x) = 0 Then 140 – 0.08x = 0 $\Rightarrow$x = 1750 Clearly, from the problem statement we can see that we only want critical points that are in the interval [0, 5000] $\therefore$ Intervals are (0, 1750), (1750,5000) In Interval (0, 1750), C'(x) = Positive C(x) is strictly increasing in [0, 1750] In Interval (1750,5000), C'(x) = Negative C(x) is strictly decreasing in [1750, 5000]. **(ii)**We have C(x) = 40,00,000 + 140x – 0.04x^2 $\therefore$ C'(x) = 140 – 0.08x C''(x) = - 0.08 C''(x)$\vert_{x=1750}$= -0.08 < 0 $\therefore$ C(x) is Maximum at x = 1750 and Local Maximum Value = C (1750)	4

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	= 4122500 Clearly, from the problem statement we can see that we only want critical points that are in the interval [0, 5000] Now we have C (0) = 40, 00000 C (1750) = 4122500 C (5000) = 3700000 ∴ Absolute Maximum value of C(x)=4122500	

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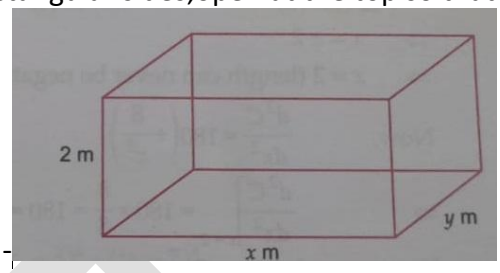
CHAPTER-6

APPLICATION OF DERIVATIVES

05 MARK TYPE QUESTIONS

Q. NO	QUESTION	MARK
1.	On the request of villagers,a construction agency designs a tank with the help of an architect.Tank consists of rectangular base with rectangular sides,open at the top so that its depth is 2m and volume is $8m^3$ as shown below:-  (i)If x and y represent the length and breadth of its rectangular base,then the relation between the variables is (a) x+y = 8 (b) x.y = 4 (c) x+y = 4 (d) $\frac{x}{y}$ = 4 (ii) If construction of tank cost Rs.70 per sq.metre for the base and Rs.45 per sq.metre for sides,then making cost 'C' expressed as a function of x is (a) C= 80+80(x+$\frac{4}{x}$) (b) C= 280x+280(x+$\frac{4}{x}$) (c) C= 280+180(x+$\frac{4}{x}$) (d) C= 70+70(x+$\frac{4}{x}$) (iii)The owner of a construction agency is interested in minimizing the cost 'C' of whole tank,for this to happen the value of x should be (a) 4m (b) 3m (c) 1m (d) 2m (iv)For minimum cost 'C' the value of y should be (a) 1m (b) 3m (c) 2m (d) 4m (v)The Pradhan of village wants to know minimum coat.The minimum cost is Rs. (a)2000 (b) 4000 (c) 11000 (d) 1000	5
2.	A helicopter is flying along the curve represented by $y = x^2+7$.A soldier placed at (3,7) wants to shoot down the helicopter when it is nearest to him. (i)If(x_1,y_1) represents the position of helicopter on the curve $y = x^2+7$,when the distance D from soldier placed at S(3,7) is minimum,then the relation between x_1,y_1 is (a)$x_1 = y_1^2+7$ (b) $y_1 = x_1^2+7$ (c) $y_1 + x_1^2 =7$ (d) $y_1^2 + x_1 = 7$. (ii)The distance 'D' expressed as a function of x_1 is (a) $D = x_1^2-6x_1 +x_1^4$(b) $D = x_1^2-6x_1 +9+x_1^4$(c) $D^2 = x_1^2-6x_1 +9+x_1^4$(d) $D^2 = x_1^2+6x_1 -9+x_1^4$ (iii)The soldierat S wants to know the enemy helicopter is nearest to soldier,then the value y_1 should be (a) 4 (b) 3 (c) 8 (d) 5 (iv)When the enemy helicopter is nearest to soldier,then the value of D should be (a) 4 units (b) 5 units (c) $\sqrt{5}$ units (d) $\sqrt{7}$ units (v) The nearest position of helicopter from soldier is (a) $(1,\sqrt{5})$ (b) (1,8) (c) (1,7) (d) $(1,\sqrt{7})$	5
3.	A rectangular garden with an area of 60 m^2 is bounded by a straight fence along three sides. The fourth side is a wall of a building. Let *x* be the length of the garden parallel to the wall, and *y* be the width of the garden perpendicular to the wall. If the rate of change of *x* with respect to time is 2 m/s, at what rate is the width *y* changing when the width is 5 m?	5

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	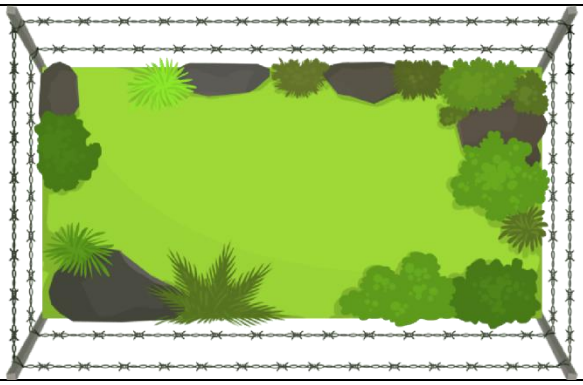	
4.	A cylindrical tank with a radius of 6 meters is being filled with water at a rate of 10 cubic meters per minute. How fast is the water level rising when the water is 4 meters deep?	5
5.	Read the following passage and answer the questions given below:  The relation between the height of the plant (y in cm) w.r.t exposure to sunlight is governed by the following equation $y = 4x - \frac{1}{2}x^2$, where x is the number of days exposed to sunlight. (i) Find the rate of growth of the plant w.r.t sunlight. (ii) what will be the height of the plant after 2 days and 4 days (iii) Find the minimum number of days it will take for the plant to grow to the maximum, height? **OR** (iii) If the height of the plant is $\frac{7}{2}cm$. Then find the number of days it has been exposed to the sunlight	5
6.	Rama wants to prepare a handmade gift box for her friend's birthday at home. For making lower part of box, she takes a square 7piece of cardboard of side 40 cm.  **Based on the above information, answer the following question:** 1. If x cm be the length of each side of the square cardboard which is to be cut off from corners of the square piece of side 40 cm , then possible value of x will be	5

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given by the interval

(A) $[0,20]$ (B) $(0,10)$(C) $(0,20)$ (D) $(0,40)$

2. Volume of the open box formed by folding up the cutting corner can be expressed as

(A) $V = x(20 - 2x)(20 - 2x)$(B) $V = x(40 - 2x)(40 - 2x)$

(C) $V = x(40 - 4x)(40 - 4x)$ (D) $V = 2x(20 - 2x)(20 - 2x)$

3. The values of x for which $\frac{dV}{dx} = 0$,are

(A) 20, $\frac{20}{3}$ (B) 0, $\frac{20}{3}$ (C) 0, $\frac{10}{3}$ (D) 10, $\frac{10}{3}$

4. Rama is interested in maximising the volume of the box. So, what should be the side of the square to be cut off so that the volume of the box is maximum?

(A)20 cm (B) $\frac{20}{3}$ cm (C) $\frac{10}{3}$ cm (D) 10 cm

5. The maximum value of the volume is

(A)$\frac{64000}{27} cm^3$(B) $\frac{128000}{27} cm^3$

(C) $\frac{8000}{27} cm^3$ (D) $\frac{16000}{27} cm^3$

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ANSWERS:

Q. NO	ANSWER	MARKS
1.	(i)option (b) x.y = 4 (ii) option (c) C= 280+180(x+$\frac{4}{x}$) (iii) option (d) 2 m (iv) option (c) 2 m (v) option (d) Rs 1000	5
2.	(i)option (b) $y_1 = x_1^2+7$ (ii) option (c) $D^2 = x_1^2-6x_1+9+x_1^4$ (iii) option (c) 8 (iv) option (c) $\sqrt{5}$ units (v) option (b) (1,8)	5
3.	Given: Area of the rectangular garden (A) = 60 m^2 Rate of change of x with respect to time ($\frac{dx}{dt}$) = 2 m/s Width of the garden (y) = 5m We want to find the rate of change of y with respect to time ($\frac{dy}{dt}$). The area of the rectangle is given by $A=xy$. Since A=60 m^2, we have the equation xy=60. Differentiate both sides of the equation with respect to time t: $\frac{\dot{d}}{d\tau}(xy) = \frac{d}{dt}(60)$. Using the product rule for differentiation: $\frac{dx}{dt}y + x\frac{dy}{dt}$=0. Given $\frac{dx}{dt}$=2, y=5, and xy=60, we can solve for $\frac{dy}{dt}$: 2·5 + $x\frac{dy}{dt}$=0. 10 + 5$\frac{dy}{dt}$=0. $\frac{dy}{dt}$=−2m/s. So, when the width y is 5 m, the width is changing at a rate of −2 m/s.	
4.	Let r be the radius of the cylindrical tank and h be the height of the water. Given r=6 meters and $\frac{dv}{at}$=10 cubic meters per minute, we want to find $\frac{dh}{dt}$when h=4 meters. The volume V of a cylinder is $V=\pi r^2 h$. Differentiate V with respect to t: $\frac{dv}{at}=2\pi rh\frac{dr}{dt}+\pi r^2\frac{dh}{dt}$ Solve for $\frac{dh}{dt}$	

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	$$\frac{dh}{dt}=\frac{\frac{dv}{dt}-2\pi rh\frac{dr}{at}}{\pi r^2}$$ Substitute r=6, $\frac{dv}{at}$=10, h=4, and $\frac{dr}{dt}$=0 (since the radius is constant): $$\frac{dh}{dt}=\frac{10-2\pi(6)(4)(0)}{\pi(6)^2}$$ $\frac{dh}{dt}=\frac{10}{36\pi}$ So, the water level is rising at a rate of $\frac{10}{36\pi}$ meters per minute when the water is 4 meters deep.	
5.	(i) $\frac{dy}{dx}=4-x$ (ii) $y(2)=4\times2-\frac{1}{2}(2)^2=6cm$ $y(4)=4\times4-\frac{1}{2}(4)^2=8cm$ (iii) $\frac{dy}{dx}=0\Rightarrow x=4\Rightarrow no\ of\ \ days=4$ and prove y is max at x=4 OR (iii) $\frac{7}{2}=4x-\frac{1}{2}x^2$ $\Rightarrow x^2-8x+7=0\Rightarrow x=1,7, x\neq7$ As maximum days are 4.	5
6.	1.c 2.b 3.a 4.b 5. b	5

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