MATHS

BOOKS - SURA MATHS (TAMIL ENGLISH)

DIFFERENTIALS AND PARTIAL DERIVATIVES

Exercise 8 1

1. Let $f(x) = \sqrt[3]{x}$. Find the linear approximation at x = 27. Use the linear approximation to approximate $\sqrt[3]{27.2}$

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2. Using the approximation to find approximate value of $(123)^{\frac{2}{3}}$

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3. Find a linear approximation for the following functions at the indicated points.

(i) $f(x) = x^3 - 5x + 12, x_0 = 2$

(ii) $g(x) = \sqrt{x^2 + 9}, x_0 = -4$

(iii) $h(x) = \frac{x}{x+1}, x_0 = 1$

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4. The radius of a circular plate is measured as 12.65 cm instead of the actual length 12.5 cm. Find the following is calculating the area of the circular plate:

(i) Absolute error

(ii) Relative error

(iii) Percentage error

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5. A sphere is made of ice having radius 10 cm. Its radius decreases from 10 cm to 9.8 cm. Find approximations for the following:

(i) change in the volume

(ii) change in the surface area

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6. The time T, taken for a complete oscillation of a single pendulam with length l, is given by the equation $T = 2\pi\sqrt{\frac{l}{g}}$, where g is a constant. Find the approximate percentage error in the calculated value of T corresponding to an error of 2 percent in the value of l.

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7. Show that the percentage error in the nth root of a number is approximately $\frac{1}{n}$ times the percentage error

in the number.

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Exercise 8 2

1. Find differential dy for each of the function :

$y = 3(3 + \sin(2x))^{\frac{2}{3}}$

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2. Find df for $f(x) = x^2 + 3x$ and evalaute it for

(i) x=2 and dx = 0.1

(ii) x=3 and dx= 0.02

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3. Find Δf and df for the function f for the indicated values of x,Δx and compare

$f(x) = x^3 - 2x^2, x = 2, \Delta x = 0.5$

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4. Assuming $\log_{10} e = 0.4343$, find an approximate value of $\log_{10} 1003$.

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5. The trunk of a tree has diameter 30 cm. During the following year, the circumference grew 6 cm.

(i) Approximately, how much did the tree's diameter grow?

(ii) What is the percentage increase in area of the tree's cross-section?

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6. An egg of a particular bird is very nearly spherical. If the radius to the inside of the shell is 5mm and radius to the outside of the shell is 5.3 mm, find the volume of the shell approximately.

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7. Assume that the cross section of the artery of human is circular. A drug is given to a patient to dilate his arteries. If the radius of an artery is increased from 2 mm to 2.1 mm, how much is cross-sectional area increased approximately?

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8. In a newly developed city, it is estimated that the voting population (in thousands) will increase according to $V(t) = 30 + 12t^2 - t^3, 0 \leq t \leq 8$ where t

is the time in years. Find the approximate change in voters for the time change from 4 to $4\left(\frac{1}{6}\right)$ year.

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9. The relation between the number of words y a person learns in x hours is given by $y = 52\sqrt{x}, 0 \leq x \leq 9$. What si the approximate number of words learned when x changes from

(i) 1 to 1.1 hour?

(ii) 4 to 4.1 hour?

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10. A circular plate expands uniformly under the influence of heat. If it's radius increases from 10.5 cm to 10.75 cm, then find an approximate change in the area and the approximate percentage change in the area.

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Exercise 8 3

1. Evaluate $\lim_{(x,y) \to (1,2)}$, g(x,y) , if the limit exist where g(x,y) $= \dfrac{3x^2 - xy}{x^2 + y^2 + 3}$

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2. Evaluate $\lim_{(x,y)\to(0,0)} \cos\left(\frac{x^3+y^3}{x+y+2}\right)$. If the limit exists.

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3. Let $f(x,y)=\frac{y^2-xy}{\sqrt{x}-\sqrt{y}}$ for $(x,y)\neq(0,0)$. Show that $\lim_{(x,y)\to(0,0)} f(x,y)=0$

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4. Evaluate $\lim_{(x,y)\to(0,0)} \cos\left(\frac{e^x \sin y}{y}\right)$, if the limit exists.

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5. Let $g(x, y) = \dfrac{x^2 y}{x^4 + y^2}$ for (x,y) $\neq$ (0,0) and f(0,0)=0.

(i) Show that $\lim_{(x,y) \to (0,0)} g(x, y) = 0$ along every line $y = mx, m \in R$.

(ii) Show that $\lim_{(x,y) \to (0,0)} g(x, y) = \dfrac{k}{1 + k^2}$, along every parabola $y = kx^2, k \in R\{0\}$.

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6. Show that $f(x, y) = \dfrac{x^2 - y^2}{y^2 + 1}$ is continous at every, $(x, y) \in R^2$.

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7. Let $g(x, y) = \dfrac{e^y \sin x}{x}$, for $x \neq 0$ and g(0,0) =1. Show that g is continous at (0,0).

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Exercise 8 4

1. Find the partial derivatives of the functions at the indicated point

$f(x, y) = 3x^2 - 2xy + y^2 + 5x + 2, (2, -5)$

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2. For each of the functions find the f_x, f_y, and show that $f_{xy} = f_{yx}$.

$$f(x, y) = \tan^{-1}\left(\frac{x}{y}\right)$$

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3. If U(x,y,z) $= \frac{x^2 + y^2}{xy} + 3z^2y,$ find

$$\frac{\partial U}{dx} + \frac{\partial U}{dy} + \frac{\partial U}{dz}$$

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4. If $U(x, y, z) = \log\left(x^3 + y^3 + z^3\right)$ find

$$\frac{\partial U}{dx} + \frac{\partial U}{dy} + \frac{\partial U}{dz}$$

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5. For each of the function find the g_{xy}, g_{yy} and g_{yx},

$g(x, y) = xe^y + 3x^2y$

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6. Let $w(x, y, z) = \frac{1}{\sqrt{x^2 + y^2 + z^2}} (x, y, z) \neq (0, 0, 0)$

. Show that $\frac{\partial^2 w}{\partial x^2} + \frac{\partial^2 w}{\partial y^2} + \frac{\partial^2 w}{\partial z^2} = 0$

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7. If $V(x, y) = e^x(x\cos y - y\sin y)$, then prove that $\frac{\partial^2 V}{\partial x^2} + \frac{\partial^2 V}{\partial y^2} = 0$

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8. If $w(x, y) = xy + \sin(xy)$, then prove that $\frac{\partial^2 w}{\partial y\,\partial x} = \frac{\partial^2 w}{\partial x\,\partial y}$

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9. If $v(x, y, z) = x^3 + y^3 + z^3 + 3xyz$, show that $\frac{\partial^2 v}{\partial y\,\partial z} = \frac{\partial^2 v}{\partial z\,\partial y}$

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10. A firm produces two types of calculators each week, x number of type A and y number of type B. The weekly revenue and cost functions (in rupees) are R(x,y) $= 80x + 90y + 0.04xy - 0.05x^2 - 0.05y^2$ and $C(x, y) = 8x + 6y + 2000$ respectively.

(i) Find the profit function P(x,y).

(ii) Find $\frac{\partial P}{\partial x}(1200, 1800)$ and $\frac{\partial P}{\partial y}(1200, 1800)$ and interpret these results.

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Exercise 8 5

1. If $w(x, y) = x^3 - 3xy + 2y^2, x, y \in R,$ find the linear approximation for w at (1,-1).

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2. Let z(x,y) $= x^2y + 3xy^4, x, y \in R.$ Find the linear approximation for z at (2,-1).

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3. If $v(x, y) = x^2 - xy + \frac{1}{4}y^2 + 7, x, y \in R,$ find the differential dv.

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4. Let W(x,y,z) $= x^2 - xy + 3\sin z, x, y, z \in R,$ Find the linear approximation at (2,-1,0).

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5. Let V(x,y,z) =xy + yz + zx, $x, y, z \in R.$ Find the differential dV.

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Exercise 8 6

1. If $u(x, y) = x^2y + 3xy^4$, $x = e^t$ and y= sin t, find $\frac{du}{dx}$ and evaluate it at t=0.

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2. If $u(x, y, z) = xy^2z^3$, $x = \sin t$, $y = \cos t$, $z = 1 + e^{2t}$, find $\frac{du}{dx}$.

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3. If $w(x, y, z) = x^2 + y^2 + z^2$, $x = e^t$, $y = e^t \sin t$ and $z = e^t \cos t$, find $\frac{dw}{dt}$.

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4. Let

$U(x, y, z) = xyz, x = e^{-t}, y = e^{-t}\cos t, z = \sin t, t \in R$

. Find $\frac{dU}{dt}$.

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5. If w(x,y) $= 6x^3 - 3xy + 2y^2, x = e^s, y = \cos s \in R,$

find $\frac{dw}{ds}$, and evaluate at s=0.

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6. If z(x,y) $= x\tan^{-1}(xy), x = t^2, y = se^t, s, t \in R,$ Find $\frac{\partial z}{\partial s}$ and $\frac{\partial z}{\partial t}$ at s=t=1.

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7. Let U(x,y) $= e^x \sin y,$ where $x = st^2, y = s^2t, s, t \in R.$ Find $\frac{\partial U}{\partial S}, \frac{\partial U}{\partial t}$ and evaluate them at s=t=1.

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8. Let z(x,y) $= x^3 - 3x^2y^3,$ where $x = se^t, y = se^{-t}, s, t \in R.$ Find $\frac{\partial z}{\partial s}$ and $\frac{\partial z}{\partial t}$

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9. W(x,y,z) = xy + yz + zx, x = u - v, y = uv, z = u + v, u, v $\in$ R. Find $\frac{\partial w}{\partial u}, \frac{\partial w}{\partial v}$ and evaluate then at $\left(\frac{1}{2}, 1\right)$.

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Exercise 8 7

1. Prove that $f(x, y) = x^3 - 2x^2y + 3xy^2 + y^3$ is homogenous, what is the degree? Verify Euler's Theorem for f.

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2. Prove that $g(x, y) = x \log\left(\frac{y}{x}\right)$ is homogenous, what is the degree? Verify Euler's Theorem for g.

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3. If $u(x, y) = \frac{x^2 + y^2}{\sqrt{x + y}}$, prove that $x\frac{\partial u}{\partial x} + y\frac{\partial u}{\partial y} = \frac{3}{2}u.$

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4. If $v(x, y) = \log\left(\frac{x^2 + y^2}{x + y}\right)$, prove that $x\frac{\partial v}{\partial x} + y\frac{\partial v}{\partial y} = 1.$

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5. If $w(x, y, z) = \log\left(\frac{5x^3y^4 + 7y^2xz^4 - 75y^3z^4}{x^2 + y^2}\right)$, find $x\frac{\partial w}{\partial x} + y\frac{\partial w}{\partial y} + z\frac{\partial w}{\partial z}$,

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Exercise 8 8

1. A circular template has a radius of 10 cm. The measurnment of the radius has an approximate error of 0.02 cm. Then the percentage error in calculating area of this template is

A. $0.2\,\%$

B. $0.4\,\%$

C. $0.04\,\%$

D. $0.08\,\%$

Answer: B

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2. The percentage error of fifth root of 31 is approximately how many times the percentage error in 31?

A. $\frac{1}{31}$

B. $\frac{1}{5}$

C. 5

D. 31

Answer: B

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3. If u(x,y) $= e^{x^2+y^2}$, then $\frac{\partial u}{\partial x}$ is equal to

A. $e^{x^2+y^2}$

B. 2xu

C. x^2u

D. y^2u

Answer: B

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4. If $v(x, y) = \log(e^x + e^y)$, then $\frac{\partial v}{\partial x} + \frac{\partial v}{\partial y}$ is equal to

A. $e^x + e^y$

B. $\frac{1}{e^x + e^y}$

C. 2

D. 1

Answer: D

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5. If $w(x, y) = x^y, x > 0$, then $\frac{\partial w}{\partial x}$ is equal to

A. $x^y \log x$

B. $y \log x$

C. yx^{y-1}

D. x log y

Answer: C

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6. If $f(x, y) = e^{xy}$, then $\frac{\partial^2 f}{\partial x \, \partial y}$ is equal to

A. xye^{xy}

B. $(1+xy)e^{xy}$

C. $(1+y)e^{xy}$

D. $(1+x)e^{xy}$

Answer: B

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7. If we measure the side of a cube to be 4 cm with an error of 0.1 cm, then the error in our calculation of the volume is

A. 0.4 cu. Cm

B. 0.45 cu. Cm

C. 2 cu.cm

D. 4.8 cu.cm

Answer: D

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8. The change in the surface area $S = 6x^2$ of a cube when the edge length varies from x_0 to $x_0 + dx$ is

A. $12x_0 + dx$

B. $12x_0 dx$

C. $6x_0 dx$

D. $6x_0 + dx$

Answer: B

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9. The approximate change in the volume V of a cube of side x metres caused by increasing the side by 1% is

A. $0.3xdxm^3$

B. $0.03xm^3$

C. $0.03x^2m^3$

D. $0.03x^3m^3$

Answer: D

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10. If $g(x, y) = 3x^2 - 5y + 2y^2, x(t) = e^t$ and $y(t) = \cos t$, then $\frac{dg}{dt}$ is equal to

A. $6e^{2t} + 5\sin t - 4\cos t \sin t$

B. $6e^{2t} - 5\sin t + 4\cos t \sin t$

C. $3e^{2t} + 5\sin t + 4\cos t \sin t$

D. $3e^{2t} - 5\sin t + 4\cos t \sin t$

Answer: A

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11. If $f(x) = \frac{x}{x+1}$, then its differential is given by

A. $-\frac{1}{(x+1)^2}$ dx

B. $\frac{1}{(x+1)^2}dx$

C. $\frac{1}{x+1}dx$

D. $-\frac{1}{x+1}dx$

Answer: B

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12. If $u(x, y) = x^2 + 3xy + y - 2019,$ then $\left(\frac{\partial u}{\partial x}\right)_{4 \quad -5}$ is equal to

A. -4

B. -3

C. -7

D. 13

Answer: C

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13. Linear approximation for g(x) = cos x at $x = \frac{\pi}{2}$ is

A. $x + \frac{\pi}{2}$

B. $-x + \frac{\pi}{2}$

C. $x - \frac{\pi}{2}$

D. $-x - \frac{\pi}{2}$

Answer: B

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14. If w(x,y,z) $=x^2(y-z)+y^2(z-x)+z^2(x-y)$, then $\frac{\partial w}{\partial x}+\frac{\partial w}{\partial y}+\frac{\partial w}{\partial z}$ is

A. xy + yz + zx

B. x(y+z)

C. y(z+x)

D. 0

Answer: D

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15. If f(x,y,z) =xy + yz + zx, then $f_x - f_z$ is equal to

A. z-x

B. y-z

C. x-z

D. y-x

Answer: A

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Government Exam Questions

1. If $u = (x - y)^2$, then $\frac{\partial u}{\partial x} + \frac{\partial u}{\partial y}$ is

A. 1

B. -1

C. 0

D. 2

Answer: C

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2. Let

$z(x, y) = xe^y + ye^{-x}, x = e^{-t}, y = st^2, s, t \in \mathbb{R}.$

Find $\frac{\partial z}{\partial s}$ and $\frac{\partial z}{\partial t}$.

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Additional Questions

1. If $y = x^4 - 10$ and if x changes from 2 to 1.99, the approximate change in y is

A. -32

B. -0.32

C. -10

D. 10

Answer: B

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2. If the radius of the sphere is measured as 9 cm with an error of 0.03 cm, the approximate error in calculating its volume is

A. $9.72cm^3$

B. $0.972cm^3$

C. $0.972\pi cm^3$

D. $9.72\pi cm^3$

Answer: D

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3. If $\log_e 4 = 1.3868$, then $\log_e 4.01 =$

A. 1.3968

B. 1.3898

C. 1.3893

D. none

Answer: C

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4. If $u = \log \sqrt{x^2 + y^2}$, then $\frac{\partial^2 u}{\partial x^2} + \frac{\partial^2 u}{\partial y^2}$ is

A. $\sqrt{x^2 + y^2}$

B. 0

C. u

D. 2u

Answer: B

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5. If $u = x^y + y^x$, then $u_x + u_y$ at x=y=1 is

A. 0

B. 2

C. 1

D. ∞

Answer: B

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6. If $u = (x-y)^4 + (y-z)^4 + (z-x)^4$ then $\sum \frac{\partial u}{\partial x} =$

A. 4

B. 1

C. 0

D. -4

Answer: C

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7. If $f(x, y, z) = \sin(xy) + \cos(xz)$, then f_{xx} is

A. $-y^2 \sin(xy) + z^2 \cos(xz)$

B. $y^2 \sin(xy) - z^2 \cos(xz)$

C. $y^2 \sin(xy) + z^2 \cos(xz)$

D. $-y^2 \sin(xy) - z^2 \cos(xz)$

Answer: D

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8. If $u = \log\left(x^3 + y^3 + z^3 - 3xyz\right)$, then $\frac{\partial u}{\partial x} + \frac{\partial u}{\partial y} + \frac{\partial u}{\partial z} =$

A. $\frac{3}{x + y + z}$

B. x+y+z

C. $-\frac{9}{(x + y + z)^2}$

D. 0

Answer: A

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9. If $f(x, y) = x^3 + y^3 - 3xy^2$, then $\frac{\partial f}{\partial x}$ at x=2, y=3 is

A. -15

B. 15

C. -9

D. 16

Answer: A

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10. If $f(x, y) = 2x^2 - 3xy + 5y^2 + 7$, then f(0,0) and f(1,1) is

A. 7,11

B. 11,7

C. 0,7

D. 1,0

Answer: A

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Fill In The Blanks

1. The approximate value of $(674)^{\frac{1}{4}}$ is _____

A. 5.002

B. 5.003

C. 5.005

D. 5.004

Answer: D

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2. The cube root of 127 is _____

A. 5.026

B. 5.26

C. 5.028

D. 5.075

Answer: A

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3. If y= sin x and x changes from $\frac{\pi}{2}$ to π, the approximate change in y is _____

A. 0

B. 1

C. $\frac{\pi}{2}$

D. $\frac{22}{14}$

Answer: A

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4. If $u = y^x$, then $\frac{\partial u}{\partial y}$=_____

A. xy^{x-1}

B. yx^{y-1}

C. 0

D. 1

Answer: A

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5. If $u = \sin^{-1}\left(\frac{x^4 + y^4}{x^2 + y^2}\right)$ and f= sin u then f is a homogenous function of degree _____

A. 0

B. 1

C. 2

D. 4

Answer: C

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6. If $x = r\cos\theta, y = r\sin\theta$, then $\frac{\partial r}{\partial x}$=_____

A. $\sec\theta$

B. $\sin\theta$

C. $\cos\theta$

D. $\operatorname{cosec}\theta$

Answer: C

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7. The percentage error in the 11th root of the number 28 is approximately _____ times the percentage error in 28.

A. $\frac{1}{28}$

B. $\frac{1}{11}$

C. 11

D. 28

Answer: B

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8. If $u = f\left(\frac{y}{x}\right)$, then $x\frac{\partial u}{\partial x} + y\frac{\partial u}{\partial y}$=_____

A. 0

B. 1

C. 2u

D. u

Answer: A

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9. If u= y sin x then $\frac{\partial^2 u}{\partial x \, \partial y}$=----------

A. cos x

B. cos y

C. sin x

D. 0

Answer: A

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10. If u is a homogenous function of x and y of degree n, then $x\frac{\partial^2 u}{\partial x^2} + y\frac{\partial^2 u}{\partial x\,\partial y}$= ---------- $\frac{\partial u}{\partial x}$.

A. n

B. 0

C. 1

D. $n - 1$

Answer: D

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Choose The Incorrect Answer

1. The approximate value of $\frac{1}{10.1}$.

A. 0.099

B. $\frac{1}{10} - 0.01$

C. $f(10) - 0.001$

D. 0.99

Answer: d

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2. The differential of $\frac{x-2}{2x+3}$ is.

A. $\frac{7}{(2x+3)^2}dx$

B. $\frac{7}{(2x+3)^2}$

C. $\frac{(2x+3-2x+4)}{(2x+3)^2}$

D. $\frac{(2x+3)(1)-(x-2)(2)}{(2x+3)^2}$

Answer: B

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3. If $u = \frac{x}{y^2} - \frac{y}{x^2}$, then

A. $\frac{\partial^2 u}{\partial x\,\partial y} = \frac{\partial^2 u}{\partial y\,\partial x}$

B. $\frac{\partial^2 u}{\partial y\,\partial x} = \frac{\partial^2 u}{\partial x\,\partial y}$

C. $\frac{\partial^2 f}{\partial x^2} = \frac{\partial^2 f}{dy^2}$

D. $\frac{\partial^2 u}{\partial x\,\partial y} = -\frac{2}{y^3} + \frac{2}{x^3}$

Answer: c

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4. If $u = \log\left(\frac{x^2 + y^2}{xy}\right)$, then

A. u is a homogenous function

B. $x\frac{\partial u}{\partial x} + y\frac{\partial u}{\partial y} = 0$

C. $\frac{x^2 + y^2}{xy}$ is a homogenous function

D. $\frac{x^2 + y^2}{xy}$ is a homogenous function of degree 0.

Answer: D

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5. Suppose that $A = \{(x, y) / a < x < b, c < y < d\} \subset R^2, F: A \to R, F$ is continous at (u,v) if

A. F is defined at (u,v)

B. $\lim_{(x,y) \to (u,v)}$ F(x,y) = L exists

C. L=F(u,v)

D. either (a) or (b) or (c) holds true

Answer: d

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2 Marks

1. A circular metal plate expands under heating so that its radius increases by 2%. Find the approximate increase in the area of the plate if the radius of the plate before heating is 10 cm.

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2. Use differentials to find $\sqrt{25.2}$

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3. If $f(x, y) = 2x^3 - 11x^2y + 3y^3$, prove that $x\frac{\partial f}{\partial x} + y\frac{\partial f}{\partial y} = 3f.$

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4. If $f(x, y) = x^2 + y^3 + 2xy^2$, find f_{xx}, f_{yy}, f_{xy} and f_{yx}

.

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3 Marks

1. Use differentials to find the value of $\sqrt{0.037}$.

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2. Find the approximate value of f(3.02) where $f(x) = 3x^2 + 5x + 3.$

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3. Using differentials find the approximate value of tan 46° if it is given that $1^\circ = 0.01745$ radians.

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4. If $f = \frac{x}{x^2 + y^2}$, then show that $x\frac{\partial f}{\partial x} + y\frac{\partial f}{\partial y} = -f.$

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5. If w=xy + z, where x=cos t, y = sin t, z=t, find $\frac{dw}{dt}$.

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5 Marks

1. If $u = \tan^{-1}\left(\frac{x^3 + y^3}{x - y}\right)$, Prove that $x\frac{\partial u}{\partial x} + y\frac{\partial u}{\partial y} = \sin 2u.$

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2. Find $\frac{\partial f}{\partial x}, \frac{\partial f}{\partial y}, \frac{\partial^2 f}{\partial x^2}, \frac{\partial^2 f}{\partial y^2}$, at x=2, y=3 if f(x,y) $= 2x^2 + 3y^2 - 8xy.$

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3. Using differential find the approximate value of cos 61, if it is given that $\sin 60^\circ 0.86603$ and $1^\circ = 0.01745$ radians.

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4. If z=f(x-cy) + F(x+cy) where f and F are any two functions and c is a constant, show that

$$c^2 \frac{\partial^2 z}{\partial x^2} = \frac{\partial^2 z}{\partial y^2}.$$

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