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DISHA Publication Inc.

A-23 FIEE Complex, Okhla Phase II

New Delhi-110020

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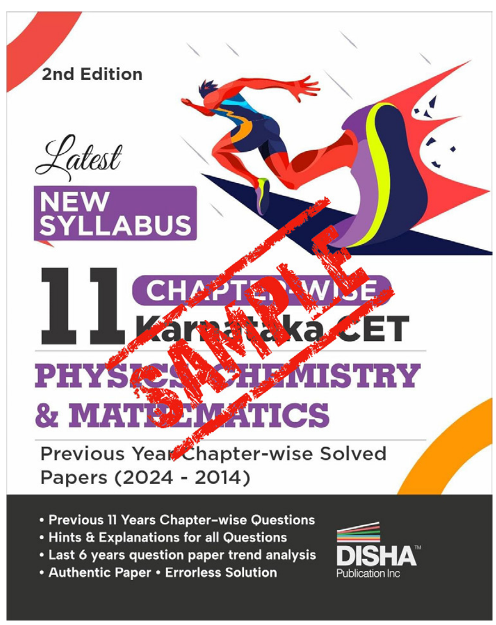

ISBN - 978-9362259813

MRP- 475/-

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Chapter 3

Motion in a Plane

1. Among the given pair of vectors, the resultant of two vectors can never be 3 units. The vectors are **[2024]**
   (a) 1 unit and 2 units (b) 2 units and 5 units
   (c) 3 units and 6 units (d) 4 units and 8 units

2. A particle is in uniform circular motion. Related to one complete revolution of the particle, which among the statements is incorrect? **[2023]**
   (a) Displacement of the particle is zero.
   (b) Average speed of the particle is zero.
   (c) Average velocity of the particle is zero.
   (d) Average acceleration of particle is zero.

3. Two objects are projected at an angle θ° and (90 – θ)°, to the horizontal with the same speed. The ratio of their maximum vertical heights is **[2022]**
   (a) $1 : \tan\theta$ (b) 1 : 1
   (c) $\tan^2\theta : 1$ (d) $\tan\theta : 1$

4. The maximum range of a gun on horizontal plane is 16 km. If $g = 10$ m s^{-2}, then muzzle velocity of a shell is **[2021]**
   (a) 160 m s^{-1} (b) $200\sqrt{2}$ m s^{-1}
   (c) 400 m s^{-1} (d) 800 m s^{-1}

5. The trajectory of a projectile is **[2021]**
   (a) semicircle
   (b) an ellipse
   (c) a parabola always
   (d) a parabola in the absence of air resistance.

6. For a projectile motion, the angle between the velocity and acceleration is minimum and acute at **[2021]**
   (a) only one point (b) two points
   (c) three points (d) four points

7. A particle starts from the origin at $t = 0$ s with a velocity of $10\hat{j}$ m s^{-1} and moves in the $x - y$ plane with a constant acceleration of $(8\hat{i} + 2\hat{j})$ m s^{-2}. At an instant when the x-coordinate of the particle is 16 m, y-coordinate of the particle is **[2021]**
   (a) 16 m (b) 28 m (c) 36 m (d) 24 m

8. Rain is falling vertically with a speed of 12 m s^{-1}. A woman rides a bicycle with a speed of 12 m s^{-1} in east to west direction. What is the direction in which she should hold her umbrella? **[2020]**
   (a) 30° towards West
   (b) 45° towards West
   (c) 30° towards East
   (d) 45° towards East

9. A wheel starting from rest gains an angular velocity of 10 rad s^{-1} after uniformly accelerated for 5 sec. The total angle through which it has turned is **[2020]**
   (a) 25π rad
   (b) 50π rad about a vertical axis
   (c) 25 rad
   (d) 100 rad

10. The trajectory of a projectile projected from origin is given by the equation $y = x - \frac{2x^2}{5}$. The initial velocity of the projectile is **[2019]**
    (a) 25 m s^{-1} (b) $\frac{2}{5}$ m s^{-1}
    (c) $\frac{5}{2}$ m s^{-1} (d) 5 m s^{-1}

11. If $\vec{A} = 2\hat{i} + 3\hat{j} + 8\hat{k}$ is perpendicular to $\vec{B} = 4\hat{j} - 4\hat{i} + \alpha\hat{k}$, then the value of 'α' is **[2017]**

(a) 1 (b) $\frac{1}{2}$ (c) –1 (d) $-\frac{1}{2}$

12. The angle between velocity and acceleration of a particle describing uniform circular motion is **[2017]**

(a) 180° (b) 45° (c) 90° (d) 60°

13. Three projectiles *A*, *B* and *C* are projected at an angle of 30°, 45°, 60° respectively. If R_A, R_B and R_C are ranges of *A*, *B* and *C* respectively then (velocity of projection is same for *A*, *B* and *C*) **[2016]**

(a) $R_A = R_B = R_C$ (b) $R_A = R_C > R_B$

(c) $R_A < R_B < R_C$ (d) $R_A = R_C < R_B$

14. The component of a vector $\vec{r}$ along *x*–axis will have a maximum value if **[2016]**

(a) $\vec{r}$ is along +ve *x*–axis

(b) $\vec{r}$ is along +ve *y*–axis

(c) $\vec{r}$ is along –ve *y*–axis

(d) $\vec{r}$ makes an angle of 45° with the *x*–axis

15. A particle is projected with a velocity v so that its horizontal range twice the greatest height attained. The horizontal range is **[2015]**

(a) $\frac{2v^2}{3g}$ (b) $\frac{v^2}{2g}$ (c) $\frac{v^2}{g}$ (d) $\frac{4v^2}{5g}$

16. The ratio of angular speed of a second-hand to the hour-hand of a watch is **[2015]**

(a) 60 : 1 (b) 72 : 1 (c) 720 : 1 (d) 3600 : 1

17. Which of the following is not a vector quantity? **[2014]**

(a) Momentum (b) Weight

(c) Potential energy (d) Nuclear spin

18. A stone is thrown vertically at a speed of 30 m s^{-1} making an angle of 45° with the horizontal. What is the maximum height reached by the stone? Take g = 10 m s^{-2}. **[2014]**

(a) 15 m (b) 30 m (c) 10 m (d) 22.5 m

ANSWER KEYS

1	(d)	**2**	(b)	**3**	(c)	**4**	(c)	**5**	(d)	**6**	(a)	**7**	(d)	**8**	(d)	**9**	(c)	**10**	(d)
11	(d)	**12**	(c)	**13**	(d)	**14**	(a)	**15**	(c)	**16**	(c)	**17**	(c)	**18**	(d)				

Chapter 3

Motion in a Plane

1. **(d)** The resultant of two vectors $\vec{A}$ and $\vec{B}$ is given by

$R_{min} \le R \le R_{max}$

$\Rightarrow$ $(A - B) \le R \le (A + B)$

For A = 8 units, B = 4 units

$4 \le R \le 12$

2. **(b)** The average acceleration will be zero. Since in one complete round the displacement is zero which implies that average velocity is also zero.

3. **(c)** Maximum height, $H = \dfrac{u^2 \sin^2\theta}{2g}$

$$H_1 = \frac{u^2 \sin^2\theta}{2g} \quad \text{... (i)}$$

$$H_2 = \frac{u^2 \sin^2(90° - \theta)}{2g} = \frac{u^2 \cos^2\theta}{2g} \quad \text{... (ii)}$$

Dividing (i) by (ii), we get $\dfrac{H_1}{H_2} = \dfrac{\tan^2\theta}{1}$

4. **(c)** Horizontal range is maximum at $\theta = 45°$

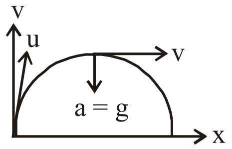
$$R_{max} = \frac{u^2 \sin 2\theta}{g} = \frac{u^2 \sin 90°}{g} = \frac{u^2}{g}$$

$$\Rightarrow u = \sqrt{R_{max}\, g} = \sqrt{16 \times 1000 \times 10} = 400 \text{ m/s}^{-1}$$

5. **(d)** In the absence of air the path of the projectile is parbolic.

6. **(a)** The acceleration due to gravity acts downwards. At maximum height velocity and acceleration is perpendicular to each other.

Thus angle will be acute for whole second half of the projectile motion but will be minimum and acute only at one point where the projectile just strikes the ground.



7. **(d)** $S_x = u_x t + \dfrac{1}{2} a_x t^2$

$16 = \dfrac{1}{2} \times 8 \times t^2$

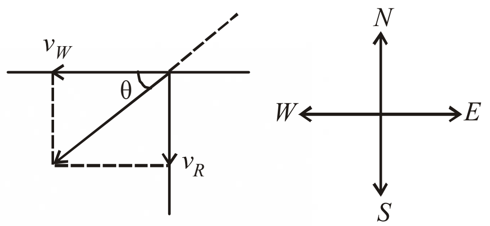
$t = 2$ sec.

$S_y = u_y t + \dfrac{1}{2} a_y t^2$

Substitute $t = 2$.

$\Rightarrow$ $10 \times 2 + \dfrac{1}{2} \times 2 \times (2)^2 = 24$ m

8. **(d)** $\tan\theta = \dfrac{v_R}{v_W} = \dfrac{12}{12} = 1 \Rightarrow \theta = \tan^{-1}(1) = 45°$



Hence, the woman should hold her umbrella 45° towards east.

9. **(c)** From equation $\omega = \omega_0 + \alpha t$

or $\omega = \alpha t \Rightarrow \alpha = \dfrac{\omega}{t} = \dfrac{10}{5} = 2 \text{ rad s}^{-2}$

Now, using displacement, $\theta = \omega_0 t + \dfrac{1}{2}\alpha t^2$

$\therefore \theta = \dfrac{1}{2} \times 2 \times (5)^2 = 25$ rad

10. **(d)** Standard equation,

$$y = x\tan\theta - \frac{1}{2} g \frac{x^2}{u^2\cos^2\theta}$$

Comparing with given equation, $\tan\theta = 1$

$\Rightarrow \theta = 45°$

$\dfrac{1}{2} g \dfrac{1}{u^2 \cos^2\theta} = \dfrac{2}{5} \Rightarrow u^2\cos^2\theta = \dfrac{25}{2}$

$\Rightarrow u = 5 \text{ m s}^{-1}$

11. **(d)** Vector $\vec{A}$ is perpendicular to $\vec{B}$.

or $\left(2\hat{i} + 3\hat{j} + 8\hat{k}\right) \cdot \left(-4\hat{i} + 4\hat{j} + \alpha\hat{k}\right) = 0$

$-8 + 12 + 8\alpha = 0$ or $\alpha = -1/2$

12. **(c)** The angle between velocity and acceleration of a particle describing uniform circular motion is 90°.

13. **(d)** Range, $R = \frac{u^2 \sin 2\theta}{g}$ or, $R \propto \sin 2\theta$

Since g is constant and u is same for all the projectiles.

So, $R_A : R_B : R_C = \sin 60° : \sin 90° : \sin 120°$

or, $R_A : R_B : R_C = \frac{\sqrt{3}}{2} : 1 : \frac{\sqrt{3}}{2} = \sqrt{3} : 2 : \sqrt{3}$

$\therefore R_A = R_C < R_B$.

14. **(a)** A vector has a maximum value along its own direction only. Hence the component of a vector $\vec{r}$ is along positive x–axis.

15. **(c)** Given, horizontal range, R = 2H

$= 2 \times \frac{v^2 \sin^2 \theta}{2g}$

For maximum height, $\theta = 90°$

$= 2 \times \frac{v^2 \sin^2 90}{2g}$

$R = \frac{v^2}{g}$

16. **(c)** For the second-hand time period,

T = 1 min.

Angular speed $\omega_s = \frac{2\pi \text{ rad}}{1 \text{ min}} = \frac{2\pi \text{ rad}}{60 \text{ s}}$

and that of the hour-hand time period,

T = 12 h

Angular speed,

$$\omega_h = \frac{2\pi \text{ rad}}{12 \text{ h}} = \frac{2\pi \text{ rad}}{12 \times 60 \times 60 \text{ s}}$$

Their corresponding ratio is

$$\frac{\omega_s}{\omega_h} = \frac{\frac{2\pi \text{ rad}}{60 \text{ s}}}{\frac{2\pi \text{ rad}}{12 \times 60 \times 60 \text{ s}}} = \frac{12 \times 60 \times 60}{60} = \frac{720}{1}$$

17. **(c)** Among the given quantities potential energy is a scalar quantity.

18. **(d)** $H_{max} = \frac{u^2 \sin^2 \theta}{2g}$

$$\therefore H_{max} = \frac{(30)^2 \sin^2 45°}{2 \times 10} = \frac{30 \times 30 \times \left(\frac{1}{\sqrt{2}}\right)^2}{2 \times 10}$$

$= \frac{45}{2} = 22.5$ m

Chapter 12

Limits and Derivatives

1. $\lim\limits_{x \to \frac{\pi}{4}} \frac{\sqrt{2}\cos x - 1}{\cot x - 1}$ is equal to **[2024]**

(a) 2 (b) $\sqrt{2}$ (c) $\frac{1}{2}$ (d) $\frac{1}{\sqrt{2}}$

2. If $\lim\limits_{x \to 0} \frac{\sin(2+x) - \sin(2-x)}{x} = A \cos B$, then the values of A and B respectively are **[2023]**

(a) 2, 1 (b) 2, 2 (c) 1, 1 (d) 1, 2

3. If $f(x) = \begin{cases} x^2 - 1, & 0 < x < 2 \\ 2x + 3, & 2 \le x < 3 \end{cases}$, the quadratic equation whose roots are $\lim\limits_{x \to 2^-} f(x)$ and $\lim\limits_{x \to 2^+} f(x)$ is **[2022, 2023]**

(a) $x^2 - 14x + 49 = 0$ (b) $x^2 - 6x + 9 = 0$
(c) $x^2 - 10x + 21 = 0$ (d) $x^2 - 7x + 8 = 0$

4. $\lim\limits_{y \to 0} \frac{\sqrt{3 + y^3} - \sqrt{3}}{y^3} =$ **[2019, 2022]**

(a) $\frac{1}{2\sqrt{3}}$ (b) $2\sqrt{3}$ (c) $\frac{1}{3\sqrt{2}}$ (d) $3\sqrt{2}$

5. If a and b are fixed non-zero constants, then the derivative of $\frac{a}{x^4} - \frac{b}{x^2} + \cos x$ is $ma + nb - p$ where **[2021]**

(a) $m = 4x^3$; $n = \frac{-2}{x^3}$; $p = \sin x$

(b) $m = \frac{-4}{x^5}$; $n = \frac{2}{x^3}$; $p = \sin x$

(c) $m = \frac{-4}{x^5}$; $n = \frac{2}{x^3}$; $p = -\sin x$

(d) $m = 4x^3$; $n = \frac{2}{x^3}$; $p = -\sin x$

6. Consider the following statements: **[2021]**

Statement 1: $\lim\limits_{x \to 1} \frac{ax^2 + bx + c}{cx^2 + bx + a}$ is 1

(where $a + b + c \neq 0$)

Statement 2: $\lim\limits_{x \to -2} \frac{\frac{1}{x} + \frac{1}{2}}{x + 2}$ is $\frac{1}{4}$

(a) only statement 2 is true
(b) only statement 1 is true
(c) both statements 1 and 2 are true
(d) both statements 1 and 2 are false

7. The right hand and left hand limit of the function $f(x) = \begin{cases} \frac{e^{\frac{1}{x}} - 1}{e^{\frac{1}{x}} + 1}, & \text{if } x \neq 0 \\ 0, & \text{if } x = 0 \end{cases}$ are respectively **[2020]**

(a) 1 and –1 (b) –1 and –1
(c) –1 and 1 (d) 1 and 1

8. $\lim\limits_{x \to 0} \left(\frac{\tan x}{\sqrt{2x + 4} - 2} \right)$ is equal to **[2020]**

(a) 3 (b) 4 (c) 6 (d) 2

9. If [x] represents the greatest function and $f(x) = x - [x] - \cos x$, then $f'\left(\frac{\pi}{2}\right) =$ **[2018]**

(a) 0 (b) 2
(c) 1 (d) does not exist

10. The value of $\lim_{\theta \to 0} \frac{1-\cos 4\theta}{1-\cos 6\theta}$ is **[2017]**

(a) $\frac{9}{4}$ (b) $\frac{4}{9}$ (c) $\frac{9}{3}$ (d) $\frac{3}{4}$

11. $\lim_{x \to 0} \frac{xe^x - \sin x}{x}$ is equal to **[2016]**

(a) 3 (b) 1 (c) 0 (d) 2

12. If the function g (x) is defined by

$$g(x) = \frac{x^{200}}{200} + \frac{x^{199}}{199} + \frac{x^{198}}{198} + ... + \frac{x^2}{2} + x + 5, \text{ then } g'(0)$$

is **[2015]**

(a) 200 (b) 5 (c) 1 (d) 100

13. If $y = f\left(x^2 + 2\right)$ and $f'(3) = 5$, then $\frac{dy}{dx}$ at $x = 1$ is .... **[2015]**

(a) 25 (b) 10 (c) 5 (d) 15

14. $\lim_{x \to 0} \frac{1-\cos x}{x^2}$ is **[2015]**

(a) 3 (b) 1/3 (c) 2 (d) $\frac{1}{2}$

15. If the function f (x) satisfies

$\lim_{x \to 1} \frac{f(x)-2}{x^2-1} = \pi$, then $\lim_{x \to 1} f(x) =$ **[2014]**

(a) 1 (b) 2 (c) 0 (d) 3

ANSWER KEYS

1	(d)	2	(b)	3	(c)	4	(a)	5	(b)	6	(c)	7	(a)	8	(d)	9	(b)	10	(b)
11	(c)	12	(c)	13	(b)	14	(d)	15	(b)										

Chapter

12

Limits and Derivatives

1. **(d)** $\lim_{x\to\frac{\pi}{4}} \frac{\sqrt{2}\cos x - 1}{\cot x - 1} = \lim_{x\to\frac{\pi}{4}} \frac{\sqrt{2}\left(\cos x - \frac{1}{\sqrt{2}}\right)\sin x}{\sqrt{2}\left(\frac{1}{\sqrt{2}}\cos x - \frac{1}{\sqrt{2}}\sin x\right)}$

$$= \lim_{x\to\frac{\pi}{4}} \frac{\left(\cos x - \cos\frac{\pi}{4}\right)\sin x}{\sin\frac{\pi}{4}\cdot\cos x - \cos\frac{\pi}{4}\cdot\sin x}$$

$$= \lim_{x\to\frac{\pi}{4}} \frac{2\sin\left(\frac{x}{2}+\frac{\pi}{8}\right)\sin\left(\frac{\pi}{8}-\frac{x}{2}\right)\cdot\sin x}{\sin\left(\frac{\pi}{4}-x\right)}$$

$$= \lim_{x\to\frac{\pi}{4}} \frac{2\sin\left(\frac{x}{2}+\frac{\pi}{8}\right)\cdot\sin\left(\frac{\pi}{8}-\frac{x}{2}\right)\cdot\sin x}{2\sin\left(\frac{\pi}{8}-\frac{x}{2}\right)\cdot\cos\left(\frac{\pi}{8}-\frac{x}{2}\right)}$$

$$= \lim_{x\to\frac{\pi}{4}} \frac{\sin\left(\frac{x}{2}+\frac{\pi}{8}\right)\cdot\sin x}{\cos\left(\frac{\pi}{8}-\frac{x}{2}\right)} = \frac{\sin\frac{\pi}{2}.\sin\frac{\pi}{4}}{\cos 0^\circ} = \frac{1}{\sqrt{2}}$$

2. **(b)** $\lim_{x\to 0}\frac{\sin(2+x)-\sin(2-x)}{x}$

$$= \lim_{x\to 0}\frac{2\cos(2)\sin(x)}{x}$$

$$= 2\cos(2)\lim_{x\to 0}\frac{\sin x}{x} = 2\cos(2)$$

$\therefore$ A = 2 & B = 2

3. **(c)** $\lim_{x\to 2^-} f(x) = \lim_{h\to 0} f(2-h)$

$$= \lim_{h\to 0}[(2-h)^2 - 1] = 3$$

$$\lim_{x\to 2^+} f(x) = \lim_{h\to 0} f(2+h) = 2(2+h)+3 = 7$$

Hence quadratic equation with roots 3 & 7 is ⇒ (x – 3)

$(x-7) = 0$

$x^2 - 10x + 21 = 0$

4. **(a)** $\lim_{y\to 0}\frac{\sqrt{3+y^3}-\sqrt{3}}{y^3}$

$$= \lim_{y\to 0}\frac{\left[\frac{(3y^2)}{2\sqrt{3+y^3}}\right]}{3y^2} = \frac{1}{2\sqrt{3}}$$

5. **(b)** $y = \frac{a}{x^4} - \frac{b}{x^2} + \cos x$

$$\Rightarrow \frac{dy}{dx} = a\left(\frac{-4}{x^5}\right) + b\left(\frac{2}{x^3}\right) - \sin x$$

$$\Rightarrow ma + nb - p = \left(\frac{-4}{x^5}\right)a + \left(\frac{2}{x^3}\right)b - \sin x$$

$$m = -\frac{4}{x^5},\ n = \frac{2}{x^3},\ p = \sin x$$

6. **(c)** $\lim_{x\to 1}\left(\frac{ax^2+bx+c}{cx^2+bx+a}\right) = \frac{a+b+c}{c+b+a} = 1.$

and $\lim_{x\to 2}\frac{\left(\frac{1}{x}+\frac{1}{2}\right)}{(x+2)} = \frac{1}{4}.$

7. **(a)** $\text{RHL} = \lim_{h\to 0} f(0+h) = \lim_{h\to 0}\frac{e^{\frac{1}{h}}-1}{e^{\frac{1}{h}}+1}$

$\left(\frac{\infty}{\infty}\text{ form}\right)$

$$\Rightarrow \text{RHL} = \lim_{h\to 0}\frac{e^{1/h}\cdot\left(-\frac{1}{h^2}\right)}{e^{1/h}\left(-\frac{1}{h^2}\right)} = 1$$

Now, LHL

$$= \lim_{h\to 0} f(0-h) = \lim_{h\to 0}\left(\frac{e^{-\frac{1}{h}}-1}{e^{-\frac{1}{h}}+1}\right) = -1.$$

8. **(d)** $\lim_{x\to 0}\left(\frac{\tan x}{\sqrt{2x+4}-2}\right)$

$$= \lim_{x\to 0}\frac{\sec^2 x}{\left(\frac{(2)}{2\sqrt{2x+4}}\right)} = 2$$

9. **(b)** $f(x) = x - [x] - \cos x$

$$f'\left(\frac{\pi}{2}\right) = \lim_{h\to 0}\frac{f\left(\frac{\pi}{2}+h\right) - f\left(\frac{\pi}{2}\right)}{h}$$

$$= \lim_{h\to 0}\frac{\left(\frac{\pi}{2}+h\right) - \left[\frac{\pi}{2}+h\right] - \cos\left(\frac{\pi}{2}+h\right) - \left(\frac{\pi}{2}\right) + \left[\frac{\pi}{2}\right] + \cos\frac{\pi}{2}}{h}$$

$$= \lim_{h\to 0}\frac{h-1-\cos\left(\frac{\pi}{2}+h\right)+1}{h}$$

$$\left\{\because \left[\frac{\pi}{2}\right] = \lim_{h\to 0}\left[\frac{\pi}{2}+h\right] = 1\right\}$$

$$= \lim_{h\to 0}\frac{1+\sin\left(\frac{\pi}{2}+h\right)}{1} = 2$$

10. **(b)** $\lim_{\theta\to 0^\circ}\frac{1-\cos 4\theta}{1-\cos 6\theta} = \lim_{\theta\to 0^\circ}\frac{\sin 4\theta\cdot(4)}{\sin 6\theta\cdot(6)}$

$$= \lim_{\theta\to 0}\frac{\cos 4\theta\,(16)}{\cos 6\theta\,(36)} = \frac{4}{9}$$

11. **(c)** $\lim_{x\to 0}\frac{xe^x - \sin x}{x} = \lim_{x\to 0}\frac{(xe^x + e^x - \cos x)}{(1)}$

$= 0$

12. **(c)** $g(x) = \frac{x^{200}}{200} + \frac{x^{199}}{199} + \frac{x^{198}}{198} + \ldots + \frac{x^2}{2} + x + 5$

$\Rightarrow g'(x) = x^{199} + x^{198} + x^{197} + \ldots + x + 1$

$\Rightarrow g'(0) = 1$

13. **(b)** $y = f(x^2+2) \Rightarrow \frac{dy}{dx} = f'(x^2+2)\,(2x)$

$\Rightarrow \left(\frac{dy}{dx}\right)_{x=1} = f'(3).(2) = 10\ \{\because f'(3) = 5\}$

14. **(d)** $\lim_{x\to 0}\frac{1-\cos x}{x^2} = \lim_{x\to 0}\frac{\sin x}{2x} = \frac{1}{2}$

15. **(b)** $\lim_{x\to 1}\frac{f(x)-2}{x^2-1} = \pi$

$\Rightarrow \lim_{x\to 1}[f(x)-2] = \pi\cdot\lim_{x\to 1}[x^2-1]$

$\Rightarrow \lim_{x\to 1} f(x) - 2 = \pi(0) \Rightarrow \lim_{x\to 1} f(x) = 2$