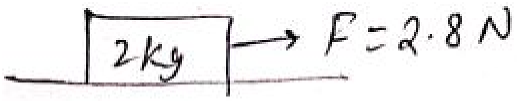
IIT – JEE: 2022 **TW TEST (MAIN)** **DATE: 17/10/21**

TOPIC: LAWS OF MOTION & FRICTION

Answer Key & Solution

1. (C)



$f_{s,\max} = \mu N$

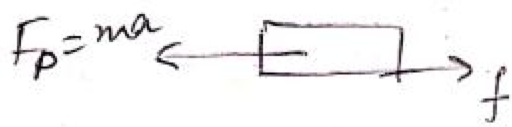
$= 0.54 \times 20$

$= 10.8 \text{ N}$

$\because \; f_{s,\max} > F$

$\therefore \; f = F = 2.8 \text{ N}$

2. (C)



$ma = F_{s,\max}$

$\Rightarrow \; ma = \mu mg$

$\Rightarrow \; a = \mu g$

3. (A)

$a = \frac{(10-6)\times 10}{16}$

$= \frac{4 \times 10}{16}$

$= 2.5 \text{ m/s}^2$

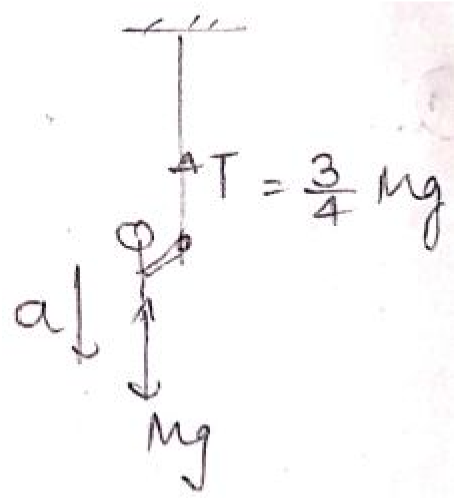
4. (A)

Action and reaction are in opposite direction.

5. (B)

Smaller steps ensures smaller friction.

6. (B)



$$Mg - \frac{3Mg}{4} = Ma$$

$$\Rightarrow\ a = \frac{g}{4}$$

7. (A)

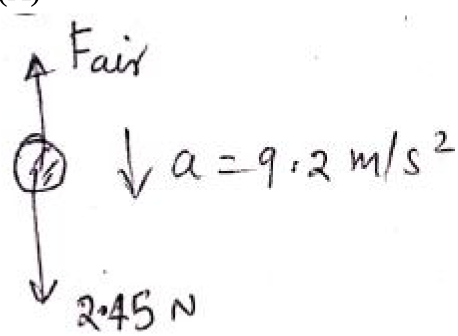
$$\tan 30^{\circ} = \frac{1}{\sqrt{3}}$$

It means block remains at rest.

8. (B)

Static friction is a self-adjusting force.

9. (A)



$$2.45 - F_a = 0.25 \times 9.2$$

$$\Rightarrow\ F_a = 0.15\,\text{N}$$

10. (B)

$$V = 72 \times \frac{5}{18} = 20\ \text{m/s}$$

& $f = \mu mg$

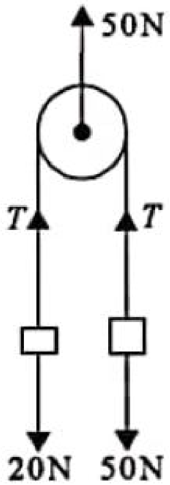
$$\Rightarrow\ ma = \mu mg\ \Rightarrow\ a = 5\ \text{m/s}^2$$

$$\therefore\ S = \frac{v^2}{2a} = \frac{400}{10} = 40\,\text{m}$$

11. (D)
Reaction force.

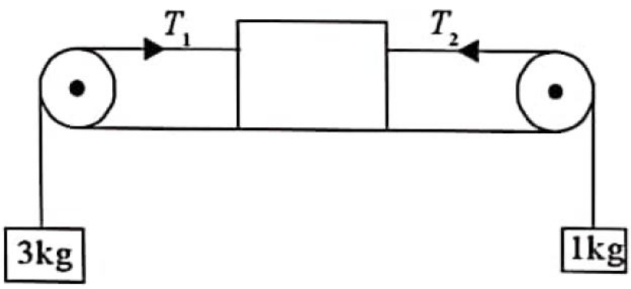
12. (C)
$\Delta P = mv$
$= 10^{-1} \times 25$
$= 2.5$
$$F = \frac{\Delta P}{\Delta t} = \frac{2.5}{0.1} = 25\,\text{N}$$

13. (A)
The masses will be lifted if the tension of the string is greater than the gravitational pull on masses.



Weight of 5 kg mass $= 5 \times 10 = 50\,\text{N}$ and 2 kg mass $= 2 \times 10 = 20\,\text{N}$
From free body diagram
$50 - 2T = 0$ or $T = 25$ N
So, 5 kg weight cannot be lifted ($\because$ acceleration = 0) but 2 kg weight will be lifted.
$\therefore$ $25 - 20 = 2a$ or $a = \frac{5}{2} = 2.5\,\text{ms}^{-2}$

14. (B)
Here, $T_1 - T_2 = 6a$,
$T_2 - 1g = 1a$ and $3g - T_1 = 3a$



Addition of the above three equations give
$10a = 3g - 1g = 2g$
or $a = \frac{2}{10} g = \frac{2}{10} \times 10 = 2\,\text{ms}^{-2}$

15. (A)

Considering free body diagram, (*for hanging mass*)

$$mg - T = ma$$

and $T = ma$ (for mass lying on surface)

Adding, $mg = (m+m)a$

Or $a = \dfrac{mg}{2m}$

$\therefore \quad a = \dfrac{g}{2} = \dfrac{10}{2} = 5\ \text{ms}^{-1}$

and $T = 1 \times 5 = 5\,\text{N}$

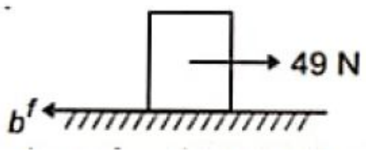
16. (A)

From constraint relation, $a_2 = 6a_1$

17. (A)

$f = \mu_s mg = 49$

$\mu_s = \dfrac{49}{10 \times 9.8} = \dfrac{49}{98} = \dfrac{1}{2}$



18. (C)

From the reference frame of *A*

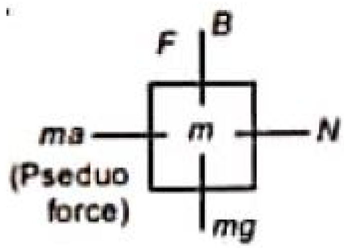
$$\mu N = mg$$

$$N = ma$$

$$N = m\left(\frac{F}{M+m}\right)$$

$$\mu m\left(\frac{F}{M+m}\right) = mg$$

$$F = \left(\frac{M+m}{\mu}\right)g$$



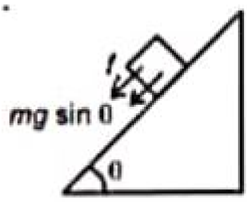
19. (A)

Retarding forces will be friction and gravitational force

$$a = -\left(g\sin 45^\circ + \mu g\cos 45^\circ\right)$$

$$= -\left(\frac{10}{\sqrt{2}} + (0.5)\frac{(10)}{\sqrt{2}}\right)$$

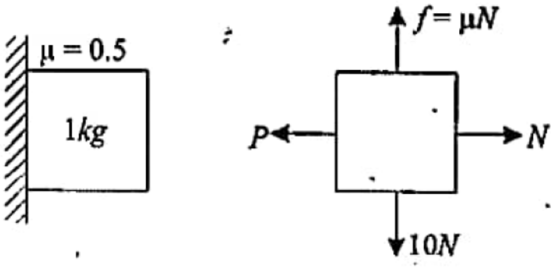
$$= \frac{15}{\sqrt{2}}$$



20. (B)

Conceptual

21. (5)

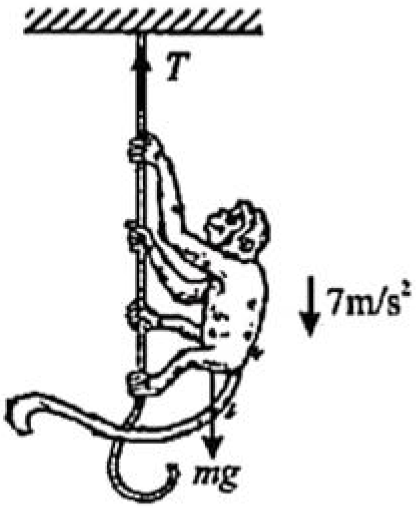


$$N = P$$
$$f_{max} = 0.5P = 10\,\text{N}$$
$$P = 20\,\text{N}$$

If applied forces is $\frac{P}{2}$, i.e. 10N,

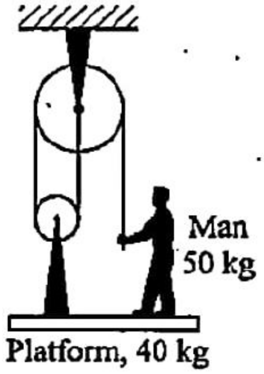
$$10 - (0.5)(10) = 1 \times a$$
$$a = 5\,\text{m/s}^2$$

22. (60)



$$mg - T = ma$$
$$(20 \times 10) - T = (20 \times 7)$$
$$200 - 140 = T$$
$$T = 60\,\text{N}$$

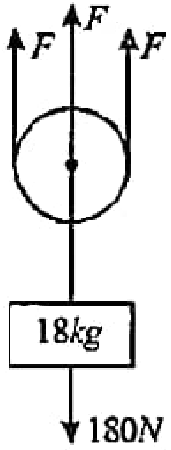
23. (300)



$$3T = 900$$

$T = 300\,\text{N}$

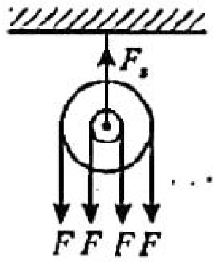
24. (240)



$3F = 180$

$F = 60\,\text{N}$

Force exerted by the ceiling on the system,

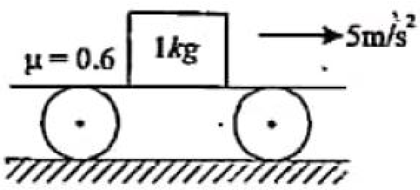


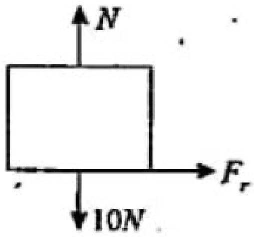
$F_s = 4F$

$= 4 \times 60$

$= 240\,\text{N}$

25. (5)





Since, there is no slipping,

Frictional force, $F_r = ma$

$= 1 \times 5 = 5\,\text{N}$

26. (10)

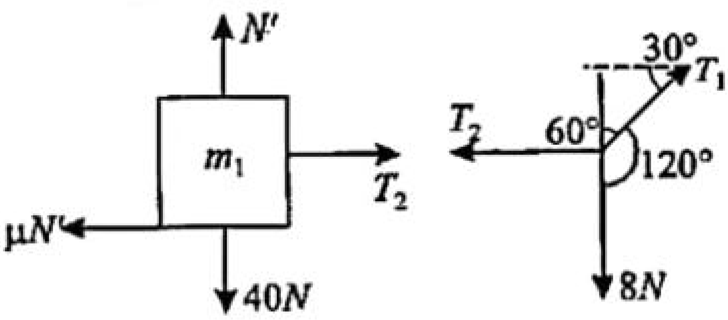
$$F = \frac{m\left|(\vec{v} - \vec{u})\right|}{t}$$

$$F = \frac{\left(10 \times 10^{-3}\,\text{kg}\right)\left[5 - (-5)\right]}{0.01}$$

$$F = \frac{10^{-2} \times 10}{10^{-2}} = 10\,\text{N}$$

27. (0.34 to 0.35)

FBD of blocks are



$N' = 40\,\text{N}$

$T_2 = 40\mu$

$$\frac{8}{\sin\left(90^\circ + 60^\circ\right)} = \frac{T_1}{\sin 90^\circ} = \frac{T_2}{\sin 120^\circ}$$

$$16 = T_1 = \frac{2T_2}{\sqrt{3}}$$

$$\frac{2T_2}{\sqrt{3}} = 16$$

$$40\mu = \frac{\sqrt{3}\times 16}{2}$$

. $$\mu = \frac{\sqrt{3}}{5} = 0.34$$

28. (4)

$F_{\text{net}} = ma$

$28000 - 2000g = 2000\,a$

$a = \dfrac{8000}{2000} = 4\,\text{m/s}^2$ upwards

29. (0.55 to 0.65)

Using $v = u + at$

Retardation will be provided by friction as well as gravitational force

$$a = \frac{u}{t}$$

$$g\sin 30^\circ + \mu g\cos 30^\circ = \frac{5}{0.5} = 10$$

$$\mu = \frac{1}{\sqrt{3}} = 0.6$$

30. (0)

$mg\sin\theta = 10(10)\sin 30^\circ = 50\,\text{N}$

Frictional force $= \mu\, mg\cos\theta = (0.7)(10)(10)\dfrac{\sqrt{3}}{2} = 35\sqrt{3}\,\text{N}$

Frictional force is sufficient to oppose gravitational force. Tension will be zero.

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TOPIC: CHEMCAL BONDING

Answer Key & Solution

31. (A)
Only NO has odd number of electros (= 7 + 8 = 15).

32. (C)
PH_3, NH_3 and SbH_3 all involve sp^3 hybridisation of the central atom. Only CH_3^+ involves sp^2 hybridisation.

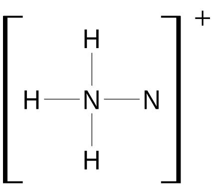
33. (C)
In $(CH_3)_3C^*OH$, C* is attached to four groups and is sp^3 hybridized.

34. (A)
O_2^- contains one unpaired electron.

35. (B)

36. (B)

37. (C)


Cl^-

38. (A)
$[(NH_2NH_2) \rightarrow H]^+$

39. (A)
BeF_3^- involves sp-hybridisation of Be.

40. (D)
Each H_2O molecule can form two H-bonds through O-atom and two H-bonds trough two H-atoms.

41. (C)
SiF_4 is symmetrical molecule. Hence its dipole moment = 0.

42. (A)

$$_{15}\mathrm{P} = 1s^2\, 2s^2\, 2p^6\, \underbrace{3s^2\, 3p_x^1\, 3p_y^1\, 3p_z^1}_{sp^3 \text{ hybridisation}}$$

43. (C)

44. (C)

45. (A)

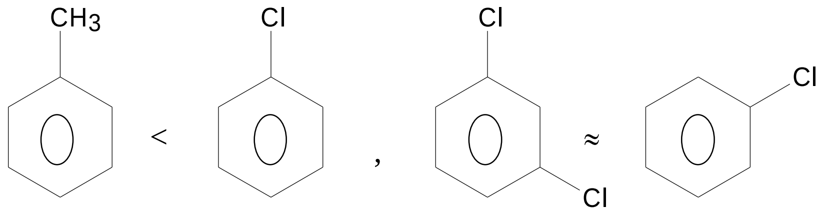
46. (B)

Most volatile hydrogen halide is the one which has least boiling point, viz, HCl.

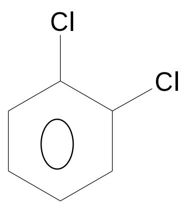
47. (C)

NF_3 and H_3O^+ are pyramidal (sp^3 bybridised) wheras NO_3^- and BF_3 are triangular planar (sp^2 hybridised) [H–N = N ≡ N is linear]

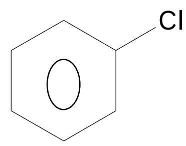
48. (B)



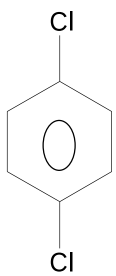
I II



= 1.72 times of



III



= 0

IV

Hence, the order is IV < I < II < III.

49. (C)

$KHF_2 \rightarrow K^+ + HF_2^-$

50. (C)

51. (16)

52. (2)

53. (0)

54. (2)

55. (62.5)

56. (0)

57. (4)

58. (6)

59. (4)

60. (9)

IIT – JEE: 2022 **TW TEST (MAIN)** **DATE: 17/10/21**

TOPIC: TRIGONOMETRIC EQUATIONS
INEQUATIONS & EQUATIONS

Answer Key & Solution

61. (D)

$\sin^2\theta + 3\cos\theta - 3 = 0$

$\Rightarrow\ 1 - \cos^2\theta + 3\cos\theta - 3 = 0$

$\Rightarrow\ \cos^2\theta - 3\cos\theta + 2 = 0$

$\Rightarrow\ \cos\theta = 1$ or $\cos\theta = 2$ (descended)

Only 1 solution in $[-\pi, \pi)$.

62. (D)

$\sec\theta + \tan\theta = \sqrt{3}$

$\Rightarrow\ \dfrac{1+\sin\theta}{\cos\theta} = \sqrt{3}$ $\Rightarrow\ \tan\left(\dfrac{\theta}{2} + \dfrac{\pi}{4}\right) = \sqrt{3}$

Hence, $\dfrac{\theta}{2} + \dfrac{\pi}{4} = n\pi + \dfrac{\pi}{3}$

$\Rightarrow\ \theta = 2n\pi + \dfrac{\pi}{6}$

In $[0, 3\pi]$ only 2 solutions.

63. (B)

$p\cos x - 9\sin x = r$ gives solutions only if $-\sqrt{p^2+q^2} \le r \le \sqrt{p^2+q^2}$

64. (C)

$\cos x + \cos y = 2$ only possible if $\cos x = \cos y = 1$

Hence in $[-\pi, \pi]$ only possibility is $x = y = 0$

$\therefore\ \cos(x-y) = \cos\theta = 1$

65. (C)

$(\sin x + \cos x)^{1+\sin 2x} = 2$, $x \in [-\pi, \pi]$

This is only possible when $\sin x + \cos x = \sqrt{2}$

And $1+\sin 2x=2$ simultaneously

$\therefore$ only solution $x=\pi/4$

66. (D)

$3^{\log_a x}+3x^{\log_a 3}=2$

We know, $3^{\log_a x}=x^{\log_a 3}$

Hence, $4.3^{\log_a x}=2 \Rightarrow 3^{\log_a x}=\left(\frac{1}{2}\right)$

$\Rightarrow \quad (\log_a x)\cdot(\log_2 3)=-1$

$\Rightarrow \quad \log_a x=\log_3\left(\frac{1}{2}\right)$

$\Rightarrow \quad x=a^{\log_3}\left(\frac{1}{2}\right)$

$\Rightarrow \quad x=\left(\frac{1}{2}\right)^{\log_3 a}=2^{-\log_3 a}$

67. (B)

$x^{\log_5 x}>5$

$\Rightarrow \quad (\log_5 x)(\log_5 x)>\log_5 5$

$\Rightarrow \quad (\log_5 x)^2>1 \Rightarrow \log_5 x\in(-\infty,-1)\cup(1,\infty)$

$\Rightarrow \quad x\in\left(0,\frac{1}{5}\right)\cup(5,\infty)$

68. (A)

$\log_{0.3}(x-1)<\log_{0.09}(x-1)$ Clearly $x>1$ (Domain)

$\Rightarrow \log_{0.3}(x-1)<\frac{1}{2}\log_{0.3}(x-1)$

$\Rightarrow \log_{0.3}(x-1)<0 \Rightarrow x-1>1 \Rightarrow x>2$

69. (B)

$|x^2-x+1|=|x^2-2x+3|$

$\Rightarrow x^2-x+1=\pm(x^2-2x+3)$

Case I: $x^2-x+1=x^2-2x+3$

$x=2$

Case II: $x^2-x+1=-x^2+2x-3$

$2x^2-3x+4=0$

$x\in\phi$

70. (A)

$$x = 2 + 2^{1/3} + 2^{2/3}$$

$$\Rightarrow\ x - 2 = 2^{1/3} + 2^{2/3}$$

Cube both sides

$$\Rightarrow\ (x-2)^3 = 2 + 2^2 + 3.2\left(2^{1/3} + 2^{2/3}\right)$$

$$\Rightarrow\ x^3 - 6x^2 + 12x - 8 = 6 + 6(x-2)$$

$$\Rightarrow\ x^3 - 6x^2 + 6x - 2 = 0$$

71. (C)

$$6\tan^2 x - 2\cos^2 x = \cos 2x$$

$$\frac{6(1-\cos 2x)}{1+\cos 2x} - (1+\cos 2x) = \cos 2x$$

Let $\cos 2x = y$

$$\Rightarrow\ 6(1-y) - (1+y)^2 = y(1+y)$$

$$\Rightarrow\ 6 - 6y - y^2 - 2y - 1 = y^2 + y$$

$$\Rightarrow\ 2y^2 + 9y - 5 = 0$$

$$\Rightarrow\ (2y-1)(y+5) = 0$$

$$\Rightarrow\ \cos 2x = \frac{1}{2}$$

72. (D)

$$\sin 3\theta = 4\sin\theta\sin 2\theta\sin 4\theta$$

$$\sin 3\theta = 2\sin\theta(\cos 2\theta - \cos 6\theta)$$

$$\sin 3\theta = 2\sin\theta\cos 2\theta - 2\sin\theta\cos 6\theta$$

$$\sin 3\theta = \sin 3\theta - \sin\theta - \sin 7\theta + \sin 5\theta$$

$$\Rightarrow\ \sin\theta = \sin 5\theta - \sin 7\theta$$

$$\Rightarrow\ \sin\theta = -2\cos 6\theta\sin\theta$$

$$\Rightarrow\ \sin\theta = 0 \text{ or } \cos 6\theta = -\frac{1}{2} \text{ (6 solutions)}$$

$$\Rightarrow\ \theta = 0, \pi$$

73. (D)

If $\cos(\alpha+\beta) = 0 \Rightarrow\ \alpha+\beta = (2n+1)\frac{\pi}{2}$

Then, $\sin(\alpha+2\beta) = \sin\left((2n+1)\frac{\pi}{2} + \beta\right)$

$$= \pm\cos\beta$$

74. (B)

Clearly, $\sin^2\theta = 1 \Rightarrow \sin\theta = \pm 1$ but $\sin\theta \neq 1$

Hence, $\sin\theta = -1$ only solution

75. (C)

$\tan\left(\pi\cos\theta\right) = \cot\left(5\pi\sin\theta\right)$

$\Rightarrow \tan\left(\pi\cos\theta\right) = \tan\left(\frac{\pi}{2} - \pi\sin\theta\right)$

$\Rightarrow \pi\cos\theta = 2\pi + \frac{\pi}{2} - \pi\sin\theta$

$\Rightarrow \left(\cos\theta + \sin\theta\right) = \frac{\left(2n+1\right)}{2}$

Clearly, $n = 0$, $n = -1$ allowed $\Rightarrow \cos\theta + \sin\theta = \pm\frac{1}{2}$

$\Rightarrow \sin\left(\theta + \frac{\pi}{4}\right) = \pm\frac{1}{2\sqrt{2}} \rightarrow$ 4 solutions in $(0, 2\pi)$

76. (C)

$\sin x + \sin 5x = \sin 2x + \sin 4x$ $\qquad \cos x \neq 1$

$2\sin 3x\cos 2x = 2\sin 3x\cos x$ $\qquad \Rightarrow x \neq 2n\pi$

$\Rightarrow \sin 3x = 0$ or $\cos 2x = \cos x$

$\Rightarrow x = \frac{n\pi}{3}$ or $2\cos^2 x - \cos x - 1 = 0$

$\left(2\cos x + 1\right)\left(2\cos x - 1\right) = 0$

$\Rightarrow \cos x = -\frac{1}{2}$

$\Rightarrow x = 2n\pi \pm \frac{2\pi}{3}$

77. (D)

Let $f\left(x\right) = 3x^2 - \left(3\sin\theta\right)x - 2\cos^2\theta$

Clearly, $f\left(1\right) < 0 \Rightarrow 3 - 3\sin\theta - 2\cos^2\theta < 0$

$\Rightarrow 2\sin^2\theta - 3\sin\theta + 1 < 0$

$\Rightarrow \left(2\sin\theta - 1\right)\left(\sin\theta - 1\right) < 0 \Rightarrow \sin\theta \in \left(\frac{1}{2}, 1\right)$

78. (A)

$\cos x = \left|1 + \sin x\right|$ $\qquad x \in [0, 3\pi]$

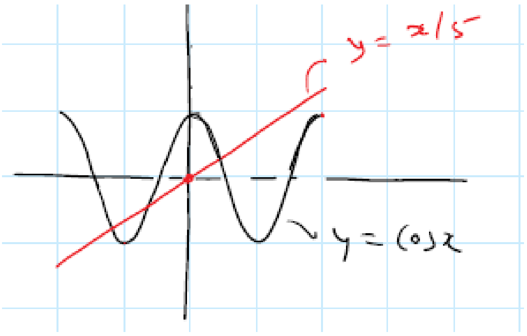
$\Rightarrow \cos x - \sin x = 1$

$\Rightarrow \cos\left(x+\frac{\pi}{4}\right)=\frac{1}{\sqrt{2}}$

3 solutions.

79. (B)

$\cos x=\frac{x}{5} \Rightarrow$ 3 solutions



80. (D)

Conceptual

81. (2)

$$\left(2^{\left(x-\sqrt{x^2-5}\right)}\right)^2-6\left(2^{x-\sqrt{x^2-5}}\right)+8=0 \qquad \ldots(\text{i})$$

Put $2^{x-\sqrt{x^2-5}}=y \Rightarrow$ equation (i) $y^2-6y+8=0$

$y=2,\ y=4$

Or $x-\sqrt{x^2-5}=1$ *or* $x-\sqrt{x^2-5}=2$

$x^2-2x+1=x^2-5$ or $x^2-4x+=x^2-5$

$x=3$ $\qquad x=\frac{9}{4}$

82. (4)

Conceptual

k can take values 2, 3, 4, 5.

83. (2)

$x^{\log 5}=5^{\log x}$

Hence equation is $2\left(5^{\log x}\right)=50$

$\Rightarrow \log x=2$

$x=10^2$

84. (1)

$4(\log_2 x)^2 + 1 = 2\log_2 y$ ...(i)

$2\log 2x \ge \log_2 y$ ...(ii)

From (i) and (ii)

$4(\log_2 x)^2 - 4\log_2 x + 1 \le 0 \Rightarrow \left(\log_2 x - \frac{1}{2}\right)^2 \le 0$

$\Rightarrow y = 2$

85. (6)

Conceptual

86. (1)

$(0.2)^{\frac{2x-1}{1-x}} < 5 \Rightarrow 5^{\frac{2x-1}{x-1}} > 5^1$

$\Rightarrow \frac{2x-1}{x-1} > 1 \Rightarrow \frac{x}{x-1} > 0$

$x \in (-\infty, 0) \cup (1, \infty)$

87. (2)

Conceptual

88. (2)

$\frac{|x+2| - x}{x} < 2 \Rightarrow \frac{|x+2| - 3x}{x} < 0$

Case I: $x \ge -2$

$\frac{x+2-3x}{x} < 0$

$\Rightarrow \frac{x-1}{x} > 0$

$x \in (-\infty, 0) \cup (1, \infty)$

Case II: $x < -2$

$\frac{-x-2-3x}{x} < 0$

$\frac{2x+1}{x} > 0$

$x \in \left(-\infty, -\frac{1}{2}\right) \cup (0, \infty)$

$\therefore$ Case I: solution $[-2, 0) \cup (1, \infty)$

Case II: Solution $(-\infty, -2)$

Ans. $x \in (-\infty, 0) \cup (1, \infty)$

89. (5)

Conceptual

90. (2)

$\left|x^2 - 2x\right| + y = 1$ & $x^2 + \left|y\right| = 1$

Only possible cases $x = 0,\ y = 1$

$x = 1,\ y = 0$