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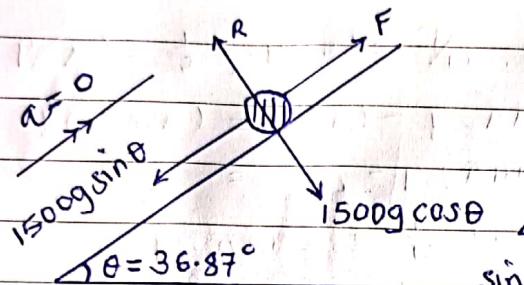
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Subject **2022** Paper code /

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(1)

Qn1.



$$F = 1500g \sin\theta + \frac{1}{4} \times 1500g \cos\theta$$

$$F = 1500 \times 9.8 \times \frac{3}{5} + \frac{1}{4} \times 1500 \times 9.8 \times \frac{4}{5}$$

$$F = 11760 \text{ N}$$

(A) up with or
into units.

$$\sin\theta = \frac{3}{5}, \cos\theta = \frac{4}{5}$$

(B) for any F,
sinθ, cosθ
tanc

(M) correct resolution,
summing, equating
with or w/o g
being substituted.

06

Qn2.

x	f	fx	fx^2
1	41	41	41
2	33	66	132
3	18	54	162
4	6	24	96
5	2	10	50

$$\sum fx = 195, \sum fx^2 = 481$$

$$\bar{x} = \frac{195}{100}$$

$$= 1.95$$

(M) substn into formula

(A) o/p

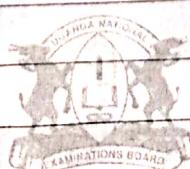
$$\text{Var}(x) = \frac{481}{100} - \left(\frac{195}{100}\right)^2$$

(M) correct substn in formula

$$= 1.0075$$

(A) correct o/p
at least 3 dp

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(2)

Ans. $h = 2 - 0 \left(\frac{1}{3} \right) \approx 1.3333$ (B1) attempting to find h .

x	y	
$\frac{1}{3}$	0.3333	
$\frac{2}{3}$	0.2903	
$\frac{1}{2}$	0.2093	
$\frac{4}{3}$	0.1429	
$\frac{5}{3}$	0.0989	
2	0.0526	
	0.3859	0.8123

(B1) for all x -values correct at least 4 d.p.s.

(B1) for 1st and last y -values at least 4 d.p.s.

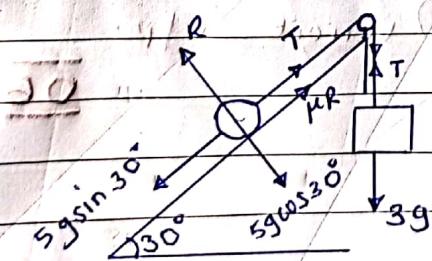
(B1) for intermediate y -values at least 4 d.p.s.

(M1) correct substn in formula

(A1) correct sol'n to 3 d.p.s.

06

Qn 4.



(B1) correct diagram with 5 forces.

(B1) perpendicular resolution

(B1) resolving parallel to the plane.

For 3kg mass: $T = 3g$ (B1) for $T = 3g$

5kg mass: $T + \mu R = 5g \sin 30^\circ$

$$3g + \mu (5g \sin 30^\circ) = 5g \sin 30^\circ \quad (B1) \quad (B1)$$

$$\mu = \frac{(5 \times 9.8 \times 0.5) - (3 \times 9.81)}{5 \times 9.8 \times \cos 30^\circ} \quad \begin{matrix} \uparrow \text{substn} \\ \uparrow \text{d.p.s} \end{matrix}$$

$$\mu = -0.1155$$

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Qn5. (i) $P(A) = \frac{1}{2}$, $P(B) = \frac{7}{12}$, $P(A \cap B) = \frac{1}{3}$

$$P(A' \cap B) = P(B) - P(A \cap B) \quad (B_1) \text{ correct expression}$$

$$\frac{1}{2} = \frac{7}{12} - P(A \cap B) \quad (m_1) \text{ correct substn.}$$

$$P(A \cap B) = \frac{1}{12} \text{ or } 0.0833 \quad (B_1) \text{ correct o/p}$$

$$P(B' \cap A) = \frac{1}{2} - \frac{1}{12} = \frac{5}{12} \text{ or } 0.4167 \quad (A_1) \text{ off ansrt} \\ (m_1) \text{ correct substn.} \quad \underline{\underline{05}} \quad 4 \text{ d.p.s}$$

Qn6. a)

97	105	D
78	85	92

(B_1) correct location

$$\frac{D - 105}{78 - 85} = \frac{105 - 97}{85 - 78} \quad (m_1) \text{ equating gradients}$$

$$D = 113 \quad (A_1) \text{ correct o/p}$$

b)

79	85	97
64	E	78

(B_1) correct location

$$\frac{E - 64}{85 - 79} = \frac{78 - 64}{97 - 79} \quad (m_1) \text{ equating gradients}$$

$$E = 68.6667 \quad (A_1) \text{ correct o/p}$$

06

Qn7. (i) $\frac{1}{2} \times 18 = 9$ (B_1)

discarded

(ii) $18 \times 18 = 324$ (B_1) (iii) $18 \times 18 = 324$ (B_1)

$$(18 \times 18) + (18 \times 18) = 144$$

$$12^2 \text{ or } (18 \times 18) - (2 \times 8 \times 18) = 144$$



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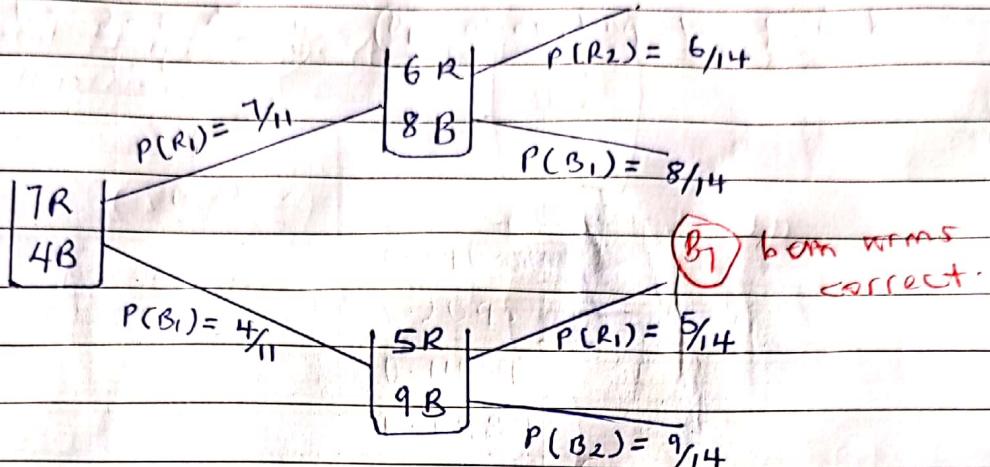
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Qn8.



a) $P(R) = \left(\frac{7}{11} \times \frac{6}{14}\right) + \left(\frac{4}{11} \times \frac{5}{14}\right)$ (m1) summing
 $= \frac{31}{77}$ or 0.4026 (A7) correct opp
at least 4 dp

b) $P(B_1 | R) = \left(\frac{4}{11} \times \frac{5}{14}\right)$ (m1) - correct subst
 $= \frac{10}{31}$ or 0.3226 (A7) correct opp
at least 4 dp

05

A n g . b)	T ₁	T ₂	D ²
	4	1	9
	3	4	1
	5	6	1
	1.5	3	2.25
	7	8	1
	6	6	0
	1.5	2	0.25
	8	6	4

$$P = 1 - \frac{6 \times 18.5}{8(8^2 - 1)}$$

$$P = 0.7798$$

$$= 0.78$$

(A7) correct opp
at least 2 dp

Comment:

significant at 5% (B1)

or not significant at 1%

or High positive correlation

correct
ranking
of T₁

(B1) $\sum D^2 = 18.5$ (B1)
correct
ranking
of T₂

correct squares
and sum

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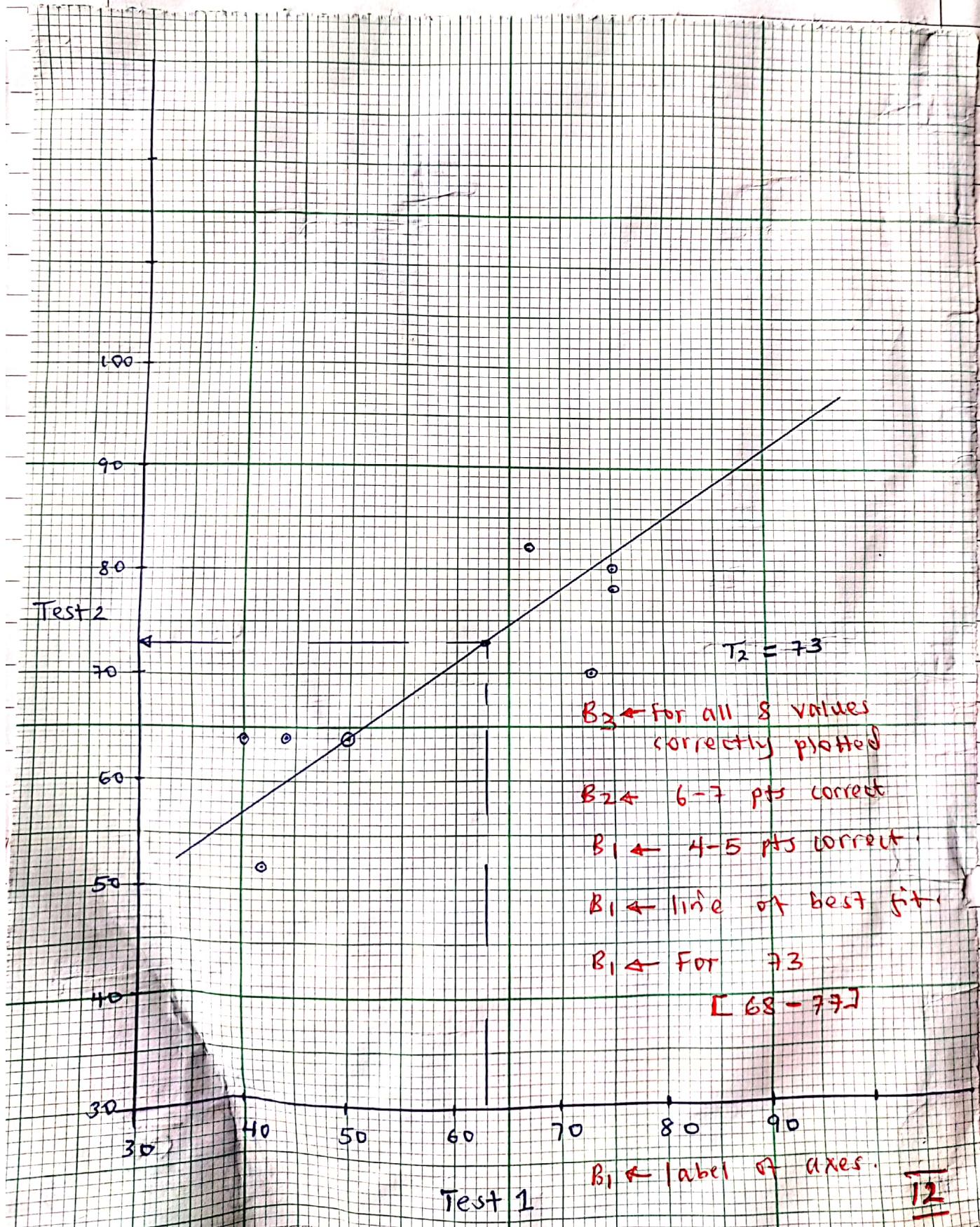
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Qn 10 a) $F = ma$ correct subtn in formula.

$$\hat{a} = \frac{1}{4} \left(\frac{4t}{t^2} \right) \text{ ms}^{-2}$$

(M1) (A1) correct opp with or
w/o unit.

$$= \begin{pmatrix} t \\ t^2/4 \\ 5/4 \end{pmatrix}$$

b) $\hat{v} = \int \begin{pmatrix} t \\ t^2/4 \\ 5/4 \end{pmatrix} dt$

$$\hat{v}(t) = \begin{pmatrix} t^2/2 \\ t^3/12 \\ 5t/4 \end{pmatrix} + C$$

(M1) correct integral with
constant seen.

at $t = 0, \hat{v} = (0, 0, 0)$

$$\begin{pmatrix} 0 \\ 0 \\ 0 \end{pmatrix} = \begin{pmatrix} 0 \\ 0 \\ 0 \end{pmatrix} + C$$

(B1) attempting to find
constant.

$$C = \begin{pmatrix} 0 \\ 0 \\ 0 \end{pmatrix}$$

$$\hat{v}(t) = \begin{pmatrix} t^2/2 \\ t^3/12 \\ 5t/4 \end{pmatrix}$$

for value of v with t substituted

at $t = 3$

$$\hat{v}(3) = \begin{pmatrix} 9/2 \\ 27/12 \\ 15/4 \end{pmatrix} = \begin{pmatrix} 4.5 \\ 2.25 \\ 3.75 \end{pmatrix}$$

(B1)

$$|v(3)| = \sqrt{(4.5)^2 + (2.25)^2 + (3.75)^2}$$

(M1) attempt to
find magnitude

$$= 6.27495 \text{ ms}^{-1}$$

(A1) correct opp atleast 1 dp
with or w/o units

c) $s(t) = \int \begin{pmatrix} t^2/2 \\ t^3/12 \\ 5t/4 \end{pmatrix}$

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$$\text{Displacement } s(t) = \begin{pmatrix} t^3/6 \\ t^4/48 \\ 5t^2/8 \end{pmatrix} + \underline{D} \cdot \text{(m)} \quad \text{attempting to find constant seen}$$

$$\text{at } t=0, s(0) = (2, -2, 3)$$

$$\begin{pmatrix} 2 \\ -2 \\ 3 \end{pmatrix} = \begin{pmatrix} 0 \\ 0 \\ 0 \end{pmatrix} + \underline{D} \cdot \text{(B1) attempting to find constant.}$$

$$\underline{D} = \begin{pmatrix} 2 \\ -2 \\ 3 \end{pmatrix}$$

$$s(t) = \begin{pmatrix} t^3/6 \\ t^4/48 \\ 5t^2/8 \end{pmatrix} + \begin{pmatrix} 2 \\ -2 \\ 3 \end{pmatrix}$$

$$= \begin{pmatrix} t^3/6 + 2 \\ t^4/48 - 2 \\ 5t^2/8 + 3 \end{pmatrix} \quad \text{(B1) correct expression of displacement from origin.}$$

$$s(3) = \begin{pmatrix} 27/6 + 2 \\ 81/48 - 2 \\ 45/8 + 3 \end{pmatrix} - \begin{pmatrix} 2 \\ -2 \\ 3 \end{pmatrix} \quad \text{(m) attempting to find } s$$

$$= \begin{pmatrix} 9/2 \\ 27/16 \\ 45/8 \end{pmatrix} \text{ m} \quad \text{(A1) correct opp of displacement with or w/o units to atleast 2 dps.}$$

$$\text{OR } s = \int_0^3 \begin{pmatrix} t^2/2 \\ t^3/12 \\ 5t^4/4 \end{pmatrix} dt$$

$$= \left[\begin{pmatrix} t^3/6 \\ t^4/48 \\ 5t^5/8 \end{pmatrix} \right]_0^3 \quad \text{(m) (B1) (B1)}$$

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$$\begin{pmatrix} 27/6 \\ 81/48 \\ 45/8 \end{pmatrix} = \begin{pmatrix} 0 \\ 0 \\ 0 \end{pmatrix} \quad (m1)$$

$$\begin{pmatrix} 9/2 \\ 27/16 \\ 45/8 \end{pmatrix} m \quad (A) \quad (12)$$

Qn 11. $x \neq x + \Delta x$, $y \neq Y + \Delta y$, $z \neq Z + \Delta z$

$$Z = \frac{x}{y}$$

$$Z + \Delta Z = X + \Delta x \quad (m1) \quad \begin{array}{l} \text{correct expression} \\ \text{error in division} \end{array}$$

$$Y + \Delta y$$

$$= \frac{(x + \Delta x)(Y - \Delta y)}{(Y + \Delta y)(Y - \Delta y)}$$

(m1) - attempting to eliminate denominator by rationalising.

$$= XY - X \Delta y + Y \Delta x - \Delta x \Delta y$$

$$+ Y^2 + (\Delta y)^2$$

since $\Delta x \ll x$, $\Delta y \ll Y$, $\Delta x \Delta y \approx 0$

and $(\Delta y)^2 \approx 0$

(B1) correct assumption made

$$(A) \quad (i) \quad Z + \Delta Z = \frac{XY - X \Delta y + Y \Delta x}{Y^2}$$

$$(A) \quad \Delta Z = \frac{XY - X \Delta y + Y \Delta x - X}{Y^2}$$

$$= \frac{Y \Delta x - X \Delta y}{Y^2}$$

$$(R.E) = \frac{\Delta Z}{Z} = \frac{Y \Delta x - X \Delta y}{Y^2} \div X \quad (m1) \quad \begin{array}{l} \text{correct} \\ \text{of R.E} \end{array}$$

$$= \frac{Y \Delta x - X \Delta y}{Y^2} \cdot \frac{Y}{X}$$

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$$= Y \Delta x + - X \Delta y$$

XY

$$\leq \frac{\Delta x}{X} + \frac{\Delta y}{Y} \quad (B1) \text{ for triangular inequality (mobile)}$$

$$\boxed{Z_{\max}} = \frac{\Delta x}{X} + \frac{\Delta y}{Y} \quad (B1) \text{ for conclusion of RE expression}$$

$$b) T_{673.165} = 0.005, T_{40.345} = 0.0005 \quad (B1) \text{ for both errors}$$

$$T_{\max} = \frac{673.165}{40.3445} = 16.6854 \quad (M1) \text{ maximizing } (B1) \text{ correct op}$$

$$T_{\min} = \frac{673.155}{40.3455} = 16.6848 \quad (M1) \text{ minimizing } (B1) \text{ correct op}$$

Interval $([16.6848, 16.6854]) \quad (B1) \text{ interval/range}$

OR from 16.6848 to 16.6854

$$16.6848 \leq T \leq 16.6854$$

$$16.6848 - 16.6854 \quad \underline{\hspace{2cm}}$$

Qn 12. (a) (i)

$$K + 4K + 9K + 9K + 4K + 1K = 31 \quad (B1) \text{ summing up}$$

$$K = \frac{1}{28} \text{ or } 0.0357 \quad (A1) \text{ and equating to 1}$$

$$f(x) = \begin{cases} \frac{1}{28}x^2; & x = 1, 2, 3 \\ \frac{1}{28}(7-x)^2; & x = 4, 5, 6 \end{cases} \quad \text{correct op}$$

$$(ii) E(x) = 1\left(\frac{1}{28}\right) + 2\left(\frac{4}{28}\right) + 3\left(\frac{9}{28}\right) + 4\left(\frac{9}{28}\right) + 5\left(\frac{4}{28}\right) + 6\left(\frac{1}{28}\right) \quad (B1) \text{ product}$$

$$5\left(\frac{4}{28}\right) + 6\left(\frac{1}{28}\right) \quad (B1) \text{ summing up}$$

$$= \frac{98}{28} \text{ or } 7 \text{ or } 3.5 \quad (A1) \text{ correct op}$$

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$$(i) E(x^2) = 1\left(\frac{1}{28}\right) + 4\left(\frac{4}{28}\right) + 9\left(\frac{9}{28}\right) +$$

$$16\left(\frac{16}{28}\right) + 25\left(\frac{25}{28}\right) + 36\left(\frac{1}{28}\right)$$

$$= \frac{378}{28} \text{ or } \frac{27}{2} \text{ or } 13.5$$

(B1) for product and sum

$$\text{Var}(x) = 13.5 - (3.5)^2$$

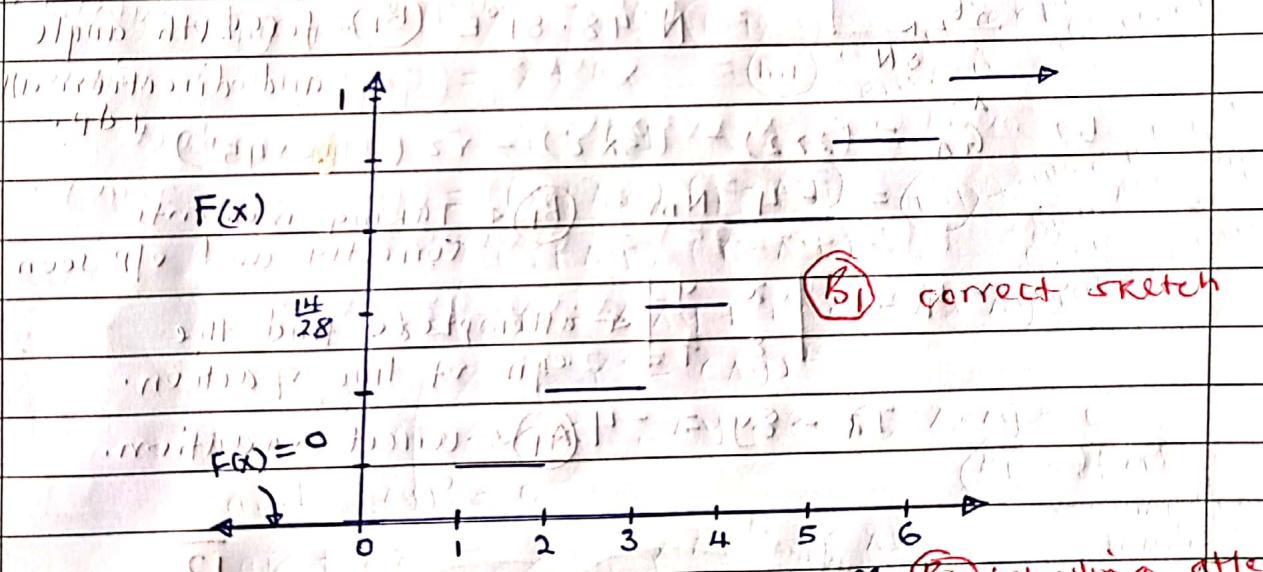
$$= 1.25 \text{ or } 5/4$$

(M1) correct substn

(A1) correct o/p

b) (i)	x	1	2	3	4	5	6
	f(x)	$\frac{1}{28}$	$\frac{4}{28}$	$\frac{9}{28}$	$\frac{9}{28}$	$\frac{16}{28}$	$\frac{1}{28}$
	F(x)	$\frac{1}{28}$	$\frac{5}{28}$	$\frac{14}{28}$	$\frac{23}{28}$	$\frac{27}{28}$	1

(B1) for cdf

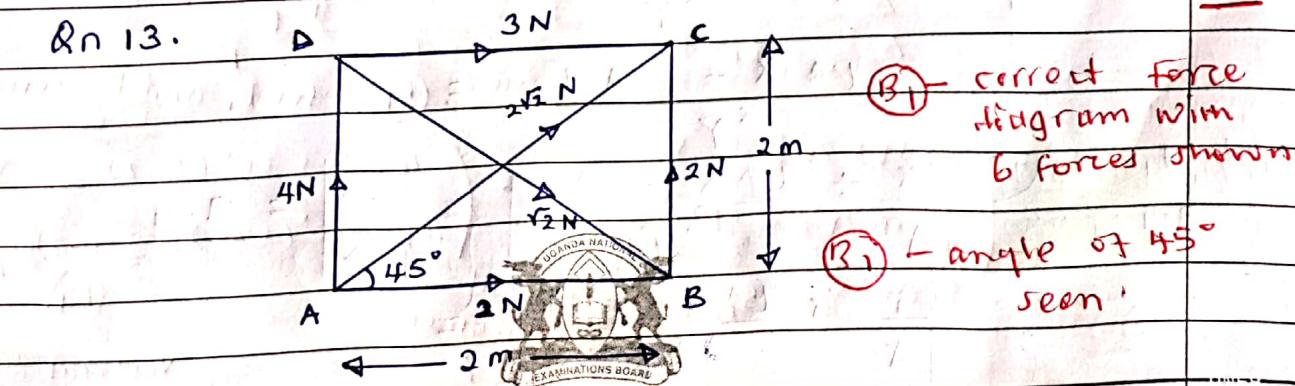


(B1) correct sketch

(B1) labelling atleast one axis correctly

T2

Qn 13.



(B1) correct force diagram with 6 forces shown

(B1) L angle of 45° seen

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$$\rightarrow x = 2 + 3 + 2\sqrt{2} \cos 45^\circ + \sqrt{2} \cos 45^\circ \quad (M1) \text{ correct}$$

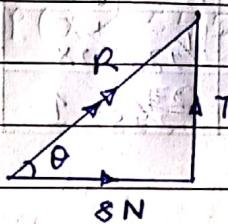
$$= 8 \text{ N} \quad (B1) \text{ correct o/p with or w/o horizontal resolution}$$

$$Y = 2 + 4 + 2\sqrt{2} \sin 45^\circ - \sqrt{2} \sin 45^\circ \quad (M1) \text{ correct vertical resolution}$$

$$= 7 \text{ N} \quad (B1) \text{ correct o/p with or w/o units}$$

$$R = \sqrt{8^2 + 7^2} \quad (M1) \text{ for finding magnitude}$$

$$= \sqrt{113} \text{ N or } 10.6301 \text{ N.} \quad (A1) \leftarrow \text{correct o/p atleast 1 dp with or w/o units.}$$



$$\tan \theta = 7/8$$

$$\theta = 41.19^\circ$$

N 48.81°E (B1) ← for both angle and direction atleast 1 dp.

$$b) G_A = (2 \times 2) - (3 \times 2) - \sqrt{2} (2 \cos 45^\circ) \quad (1 \text{ dp.})$$

$$= -4 \text{ Nm.} \quad (B1) \leftarrow \text{Taking moments correctly and o/p seen}$$

$$7x - 8y = -4 \quad (A1) \leftarrow \text{attempt to find the eqn of line of action.}$$

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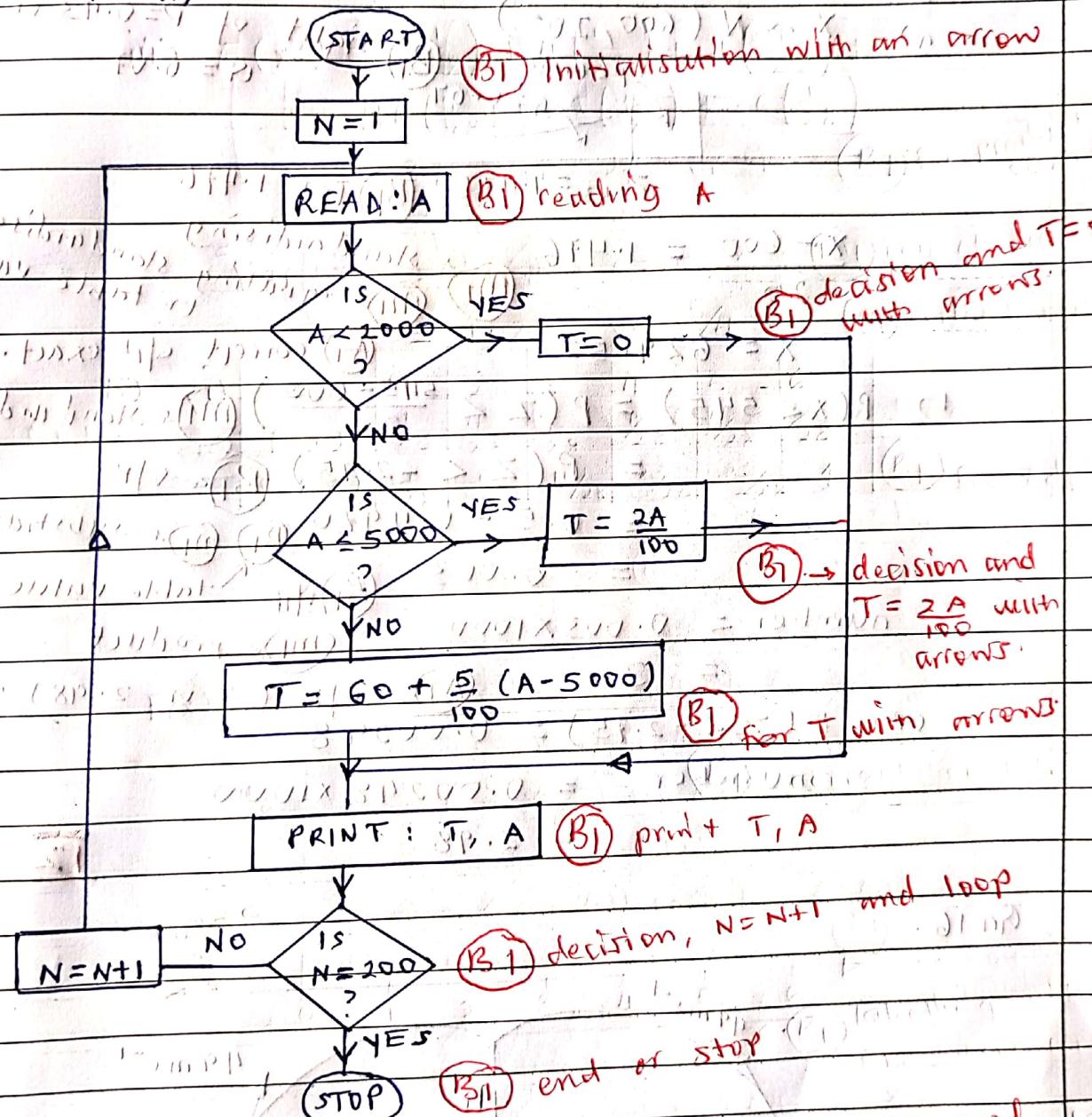
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Qn 14. a)



Purpose: (B1) - If all the 8 B's are earned

N	A	T	(B1)
1	1500	0	(B1)
2	3500	70	(B1)
3	9000	260	(B1)

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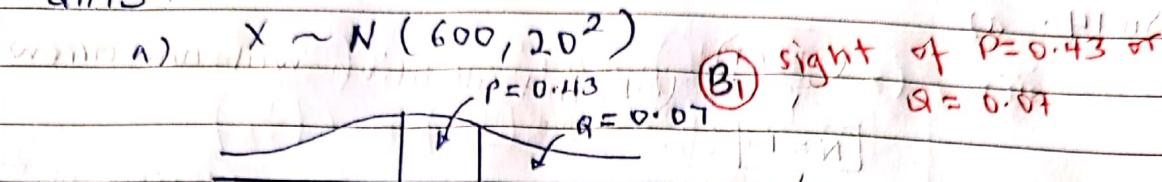
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Qn 15 .



$$Z_{0.43} = 1.476 \quad (B_1) \text{ for } 1.476$$

$$\frac{x - 600}{20} = 1.476 \quad (M_1) \text{ standardising}$$

$$x = 629.52 \quad (A_1) \text{ correct s/p exact.}$$

$$b) P(x < 545) = P\left(z < \frac{545 - 600}{20}\right) \quad (M_1) \text{ standardising}$$

$$= P(z < -2.75) \quad (B_1) \text{ or } 0/P$$

$$= 0.5 - 0.4970 \quad (B_1) \text{ m1 + subtraction}$$

$$= 0.003 \quad (B_1) \text{ m1 + table value}$$

$$\text{number} = 0.003 \times 1000 \quad (M_1) \text{ m1 + product}$$

$$= (3) \quad (A_1) \text{ or } 0/P (3 \text{ or } 2.98)$$

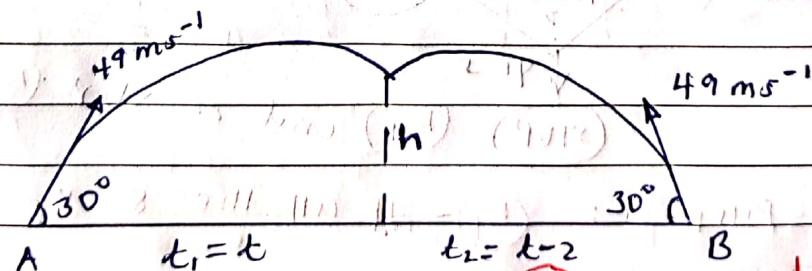
$$\text{OR, } P(z < -2.75) = 0.00298$$

$$\text{number} = 0.00298 \times 1000$$

$$= 2.98 \quad (M_1)$$

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Qn 16 .



(B1) for t_1 and t_2 correct.

$$S_A = \left(49 \cos 30^\circ t \right), S_B = \left(49 \cos 30^\circ (t-2) \right)$$

$$49 \sin 30^\circ t - \frac{g t^2}{2} \quad (B_1)$$

Vertically, $S_A = S_B$ (vertical displacement from A)



vertical displacement from B

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$$49 \times 0.5t - 4.9t^2 = 49 \times 0.5(t-2) - 4.9(t-2)^2$$

$$19.6t = 19.6 + 49$$

$$t = 3.5 \text{ seconds.}$$

(m1) equating vertical components.

(m1) & attempting to solve t.

(A1) correct o/p with or w/o units.

$$h = (49 \times \frac{1}{2} \times 3.5) - 4.9 \times 3.5^2$$

$$h = 25.725 \text{ m}$$

$$\text{Horizontally } AB = S_A + S_B$$

$$= (49 \cos 30 \times 3.5) + (49 \cos 30^\circ (3.5-2))$$

$$= 212.1762 \text{ m}$$

(B1) for sp with t substituted.

(B1) for SB

(A1) addition. with t substituted

(correct o/p to atleast 1 dp with or w/o units.)

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