(1)

Let the number be x_1, x_2, x_3, x_4 and x_5 in ascending order

$x_3 = 30 \qquad x_5 - x_1 = x_4 \Rightarrow x_5 = x_1 + x_4$

$x_5 = 2x_2, \; x_4 = 2x_1, \; x_2 = \frac{x_5}{2} = \frac{3x_1}{2}$

$\frac{1}{5}(x_1 + x_2 + x_3 + x_4 + x_5) = 7.4$ M1

$\frac{1}{5}(3x_1 + 3x_1 + \frac{3}{2}x_1 + 30) = 7.4$ M1

$x_1 = \frac{14}{15}$ B1

$x_2 = \frac{3}{2}\left(\frac{14}{15}\right) = 1.4$ A1

$x_4 = 2\left(\frac{14}{15}\right) = \frac{28}{15}$ A1

$x_5 = 2(1.4) = 2.8$ A1

(2)

a)

$R = v\sqrt{13}\cos\theta$

$240 = v\sqrt{13}\cos\theta$ B1 $\quad \theta = \tan^{-1}(\frac{3}{2}) = 56.31°$ B1

$v = \frac{240}{\sqrt{13}\cos 56.31} = 120\,ms^{-1}$ B1

b) $y = x\tan\theta - \frac{1}{2}g\frac{x^2}{u^2}(1 + \tan^2\theta)$

M1

$y = x(\frac{3}{2}) - \frac{1}{2}g\frac{x^2}{u^2}(1 + (\frac{3}{2})^2)$

$y = \frac{3}{2}x - \frac{13}{8}g\frac{x^2}{u^2}$ A1

3 a) let the distance be d

d	20	28
27	24	21

M1

$$\frac{d-20}{27-24} = \frac{20-28}{24-21} \quad B1$$

$$d = 12\text{ km} \quad M1$$

b) let the liquid be l

28	29	33
21	l	13

$$\frac{l-21}{29-28} = \frac{13-21}{33-28} \quad M1$$

$$l = 19.4 \text{ litres} \quad M1$$

4

$$P(X=2) = \frac{2}{k} = \frac{2}{k} \quad B1$$

$$\Rightarrow k = 15. \quad M1$$

$$S_n = \frac{n}{2}(2a + (n-1)d) \qquad d = \frac{2}{k} - \frac{1}{k} = \frac{1}{k}, \quad a = \frac{1}{k}$$

but $S_n = \sum_{\text{all } x} P(X=x) = 1$

$$1 = \frac{n}{2}\left[2\left(\frac{1}{15}\right) + (n-1)\left(\frac{1}{k}\right)\right] \quad M1$$

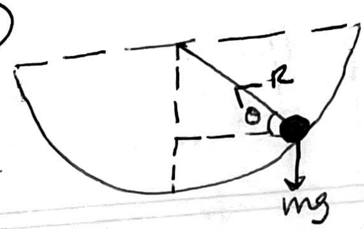
$$30 = 2n + (n^2 - n)$$

$$n^2 + n - 30 = 0$$

$$n = \frac{-1 \pm \sqrt{1 + 4(30)}}{2} \quad M1$$

$$n = \frac{-1+11}{2} = \underline{5} \quad M1$$

(5)



$\sin\theta = \frac{1.2}{2}$

$\theta = \sin^{-1}(0.6) = 36.89°$

$r = \sqrt{2^2 - 1.2^2} = 1.6m$

$\uparrow R\sin 36.89 = mg$ — (i)

$\rightarrow R\cos 36.89 = mw^2 \times 1.6$ — (ii)

(i) ÷ (ii)

$\tan 36.89 = \frac{g}{1.6w^2}$

$w = \sqrt{\frac{9.8}{1.2\tan 36.89}} = 2.8567 ms^{-1}$

b $w = \frac{2\pi}{T}$ $T = \frac{2\pi}{w} = \frac{2\pi}{2.8567} = 2.1995 s$

(6)

let $z = a - b$

$z + \delta z = (a + ea) - (b + eb)$ $\delta z = (a - b) - z + (ea - eb)$

$\delta z = ea - eb$.

R.E $= \left|\frac{ea - eb}{a - b}\right|$

maximum relative error $= \left|\frac{ea}{a-b}\right| + \left|\frac{eb}{a-b}\right|$

Percentage error in $a-b$ $= \left(\left|\frac{ea}{a-b}\right| + \left|\frac{eb}{a-b}\right|\right) \times 100$

$\cancel{= \left|\frac{ea}{a-b}\right| \times 100 + \left|\frac{eb}{a-b}\right| \times 100}$

$\% ea = \frac{ea}{a} \times 100$

$|ea| = \frac{0.05 \times 84.1}{100} = 0.04205$

$|eb| = \frac{0.5 \times 4.3}{100} = 0.0215$

$|a - b| = 84.1 - 4.3 = 79.8$

% error in $a-b$ $= \left[\left(\frac{0.04205}{79.8}\right) + \left(\frac{0.0215}{79.8}\right)\right] \times 100$

$= 0.0796\%$

7

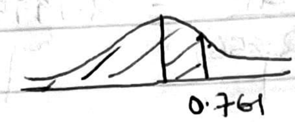
$\mu = np = 120 \times \frac{1}{10} = 12$. $\quad q = 9/10$

$\sigma^2 = npq = 12 \times \frac{9}{10} = 10.8$

~~$P(X<15)$~~ ~~$= P(X \le 14)$~~

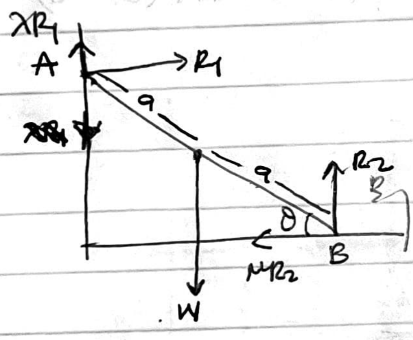
~~$P(X \le 14)$~~ $P(X<15) = P(X \le 14.5)$

$P(X \le 14.5) = P\left(Z < \frac{14.5-12}{\sqrt{10.8}}\right) = P(Z<0.761)$



$P(Z<0.761) = 0.5 + 0.2767 = 0.7767$

8



(a) $W \times a\cos\theta + \mu R_2 \times 2a\sin\theta = 2a\cos\theta \times R_2$

Resolving vertically: $W + \lambda R_1 = R_2$

Resolving horizontally: $R_1 = \mu R_2$. $\quad W + \lambda\mu R_2 = R_2$

$W = R_2(1+\lambda\mu)$.

$R_2(1+\lambda\mu)\, a\cos\theta + \mu R_2 \times 2a\sin\theta = 2a\cos\theta \times R_2$

$1 + \lambda\mu + 2\mu\tan\theta = 2$

$1 + \lambda\mu + 2\mu\left(\frac{5}{12}\right) = 2$

$6 + 6\lambda\mu + 5\mu = 12$

$5\mu + 6\lambda\mu - 6 = 0$.

9

Jinja	Kampala	R_J	R_K	d	d^2
45	73	3.5	7	-3.5	12.25
38	82	2	8	-6	36
65	61	5	5	0	0
80	43	8	2	6	36
70	48	6	3.5	2.5	6.25
45	65	3.5	6	-2.5	6.25
25	90	1	9	-8	64
95	30	9	1	8	64
77	48	7	3.5	3.5	12.25
		B1	B1		$\Sigma d^2 = 237$

$$\rho = 1 - \frac{6\Sigma d^2}{n(n^2-1)}$$

$$= 1 - \frac{6(237)}{9(9^2-1)} \text{ M1} = -0.975 \text{ A1}$$

ii) Significant at 5% B1

$\bar{x} = 60 \quad \bar{y} = 60 \quad G(60, 60)$

b i) 35 ~~marks~~ A1

ii) 66 ~~marks~~ M1 A1

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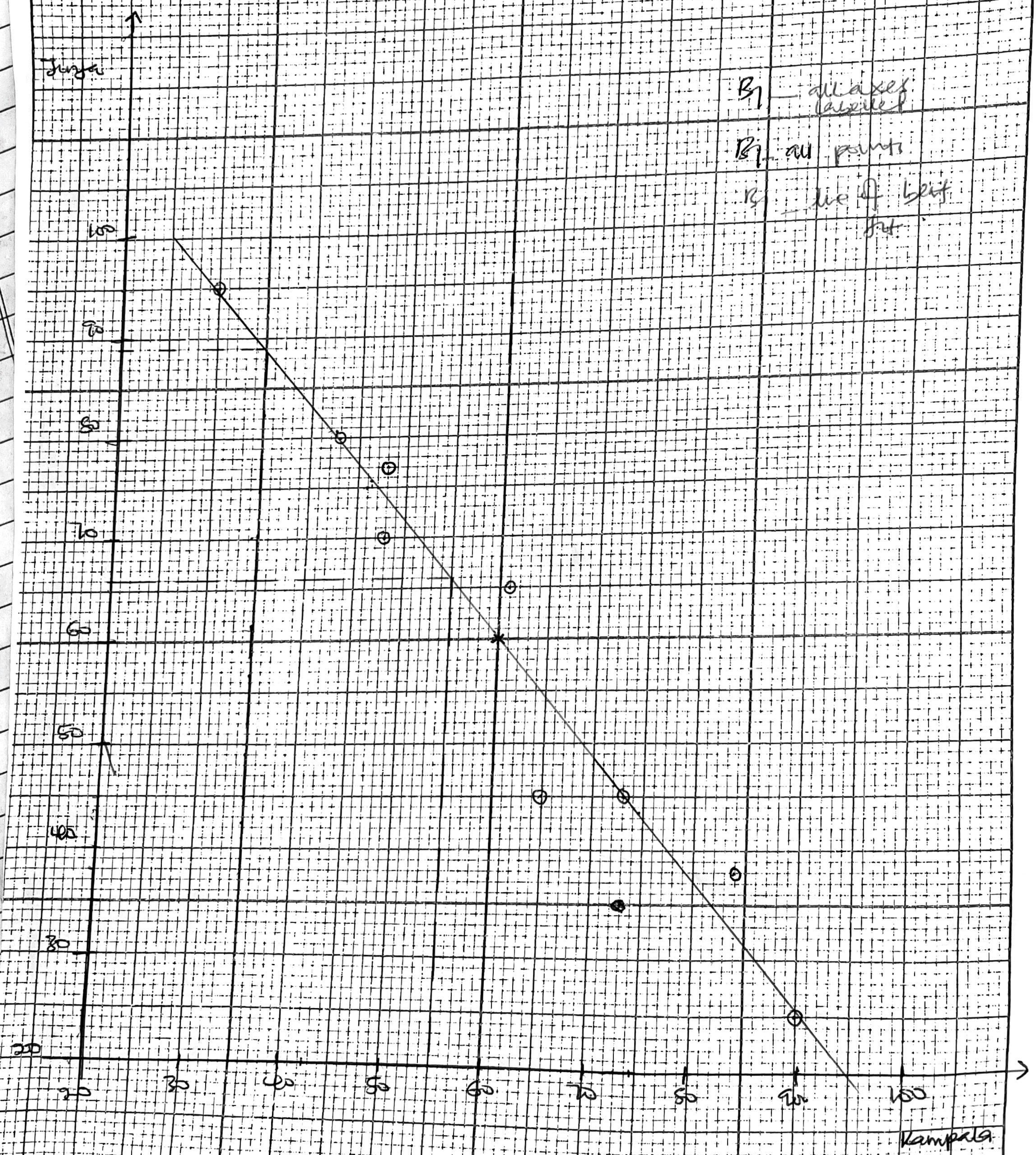


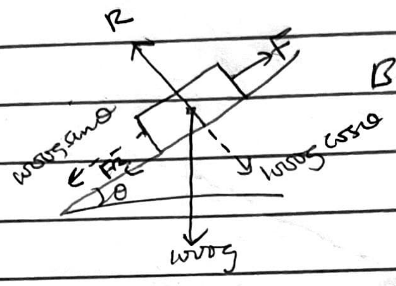
10

at constant velocity, $a = 0$.

driving force = resisting force.

$$F = \frac{15 \times 1000}{100/3} = 450N$$

b i)



$F_R \propto V^2$

$$F_R = kV^2 \quad k = \frac{450}{(100/3)^2} = 0.405$$

along incline plane at steady speed

$$F = 0.405 \times (100/9)^2 + 1000 \times 9.8 \times \frac{1}{25} = 442N.$$

$$P = FV = 442 \times \frac{100}{9} = \frac{44200}{9} W$$

when engine is shut off, driving force is zero.

$$0 - 442 = 1000a$$

$$a = \frac{-442}{1000} = -0.442 ms^{-2}$$

from $v = u + at$

$$0 = \frac{100}{9} - 0.442t$$

$$t = \frac{100}{9 \times 0.442} = 25.1383 s.$$

11

x	y_0+y_n	$y_1+y_2+\dots+y_{n-1}$
2	2	
3.6	~~2.8~~	2.2326
5.2		2.5373
6.8		2.8235
8.4		3.0879
10	3.3333	
	5.3333	10.68137

B1 — ~~y_0, y_5~~ x_n

B1 — y_0, y_5 and y_1 — y_4

~~B1 — y_1 — y_4~~

B1 — x_n

$$\int_2^{10} \frac{x}{\sqrt{x-1}}\,dx \approx \frac{1}{2}\times(1.6)\left[5.3333 + 2(10.68137)\right] \quad M1$$

$\approx$ ~~17.090~~ 21.357 B1

b i)

let $\sqrt{x-1} = u$

$x - 1 = u^2$

$dx = 2u\,du$

$x = u^2+1$

for $x=2$, $u=1$; for $x=10$, $u=3$ B1

$$\int_1^3 \frac{u^2+1}{u}\cdot 2u\,du = 2\int_1^3 u^2+1\,du = 2\left[\frac{u^3}{3}+u\right]_1^3 \quad M1$$

$$= 2\left[\left[\frac{27}{3}+3\right] - \left(\frac{1}{3}+1\right)\right] \quad M1$$

$$= 21.333 \quad A1$$

$|\text{error}| = |21.333 - 21.357| = 0.02356$ M1 A1

~~% error = $\frac{0.02356}{21.3}$~~

iii) — ~~increasing~~ decreasing the strip width (increasing number of strips) B1

— increase number of decimal places in ~~tabulation~~ (manipulations) ~~tabulation~~ B1

4 12

a) P(A winning on first throw) = $1/4$
P(A winning on second throw) = $3/4 \times 3/4 \times 1/4$
P(A winning on third throw) = $3/4 \times 3/4 \times 3/4 \times 3/4 \times 1/4$

$$P(A\ \text{winning}) = 1/4 + (3/4)^2 \times 1/4 + (3/4)^4 \times 1/4 + (3/4)^6 \times 1/4 + \ldots$$
$$= 1/4\left(1 + (3/4)^2 + (3/4)^4 + (3/4)^6 + \ldots\right)$$

$$1 + (3/4)^2 + (3/4)^4 + (3/4)^6 + \ldots = \frac{1}{1 - 9/16} = \frac{16}{7}$$

$$P(A\ \text{winning}) = 16/7 \times 1/4 = \underline{4/7}$$

b) $P(Z) = 1 - 2/5 - 7/20 = 1/4$

i) $P(D) = P(D \cap X) + P(D \cap Y) + P(D \cap Z)$
$= 2/5 \times 2/25 + 7/20 * 1/20 + 1/4 \times 1/20$
$= \underline{0.0795}$

ii) $P(Y \cup D) = P(Y) + P(D) - P(Y \cap D)$
$= 7/20 + 0.0795 - 7/400$
$= 0.3945$

iii) $P(X/D') = \dfrac{P(X \cap D')}{P(D')}$

$P(X \cap D') = 2/5 - (2/5 \times 2/25) = 0.0248$
$P(D') = 1 - 0.0795 = 0.9205$

$P(X/D') = \dfrac{0.0248}{0.9205} = 0.0526$

13)

$a_1 = \frac{dv_1}{dt} = 2\underset{\sim}{i} - 6t\underset{\sim}{j} \ \text{ms}^{-2}$

$a_2 = \frac{dv_2}{dt} = 3t^2\underset{\sim}{i} + \cancel{6t}\ 2\underset{\sim}{j} \ \text{ms}^{-2}$ B1

Perpendicular

$a_1 \cdot a_2 = 0$

$(2\underset{\sim}{i} - 6t\underset{\sim}{j}) \cdot (3t^2\underset{\sim}{i} + 2\underset{\sim}{j}) = 0$ M1

$6t^2 - 12t = 0 \qquad 6t(t-2) = 0$

$\underline{\underline{t = 2\,s}}$ A1

b) for $t = 2$

$v_1 = 4\underset{\sim}{i} - 12\underset{\sim}{j} \qquad v_2 = 8\underset{\sim}{i} + \underset{\sim}{j}$

$_1V_2 = \begin{pmatrix} 4 \\ -12 \end{pmatrix} - \begin{pmatrix} 8 \\ 1 \end{pmatrix} = \begin{pmatrix} -4 \\ -13 \end{pmatrix} \text{ms}^{-1}$ B1

B1

c)

$r_1 = 2\begin{pmatrix} 4 \\ -12 \end{pmatrix} = \begin{pmatrix} 8 \\ -24 \end{pmatrix} \text{m}$ M1 B1

$r_2 = 2\begin{pmatrix} 8 \\ 1 \end{pmatrix} = \begin{pmatrix} 16 \\ 2 \end{pmatrix} \text{m}$ B1

$_1r_2 = \begin{pmatrix} 8 \\ -24 \end{pmatrix} - \begin{pmatrix} 16 \\ 2 \end{pmatrix}$ M1

$= \begin{pmatrix} -8 \\ -26 \end{pmatrix} \text{m}$ B1

$|_1r_2| = \sqrt{8^2 + 26^2}$ M1 $= \underline{27.2029\,\text{m}}$ A1

(14)

x	-2	-1	0	1	2	
$y = 2\sin x$	-1.82	-1.68	0	1.68	1.82	B1
$y = x$	-2	-1	0	1	2	B1

b.

let $y = x^3 - 3x^2 + 1$

x	-1	0	1	2	3	
y	-3	1	-2	-3	1	B1

~~There are roots in $(-3, 1)$ $(1, -2)$~~

there are roots in the ranges $(-1, 0)$ A1, $(0, 1)$ A1 and $(2, 3)$ A1

since there are change in sign of y.

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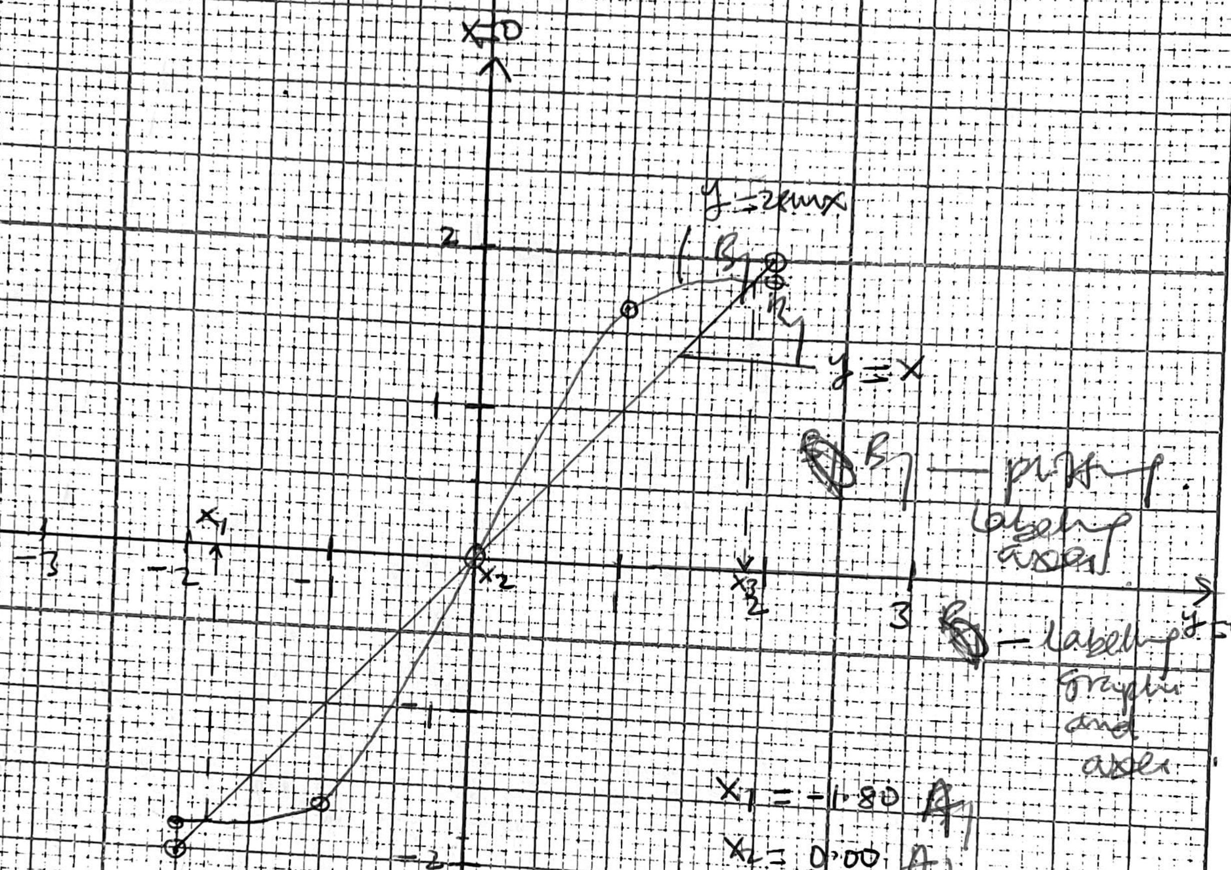


$X_1 = -1.80$ A1

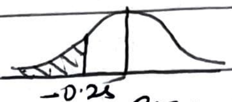
$X_2 = 0.00$ A1

$X_3 = 1.85$ B1

15

$W \sim N(10, 4)$

a) $P(W < 9.5) = P\left(Z < \frac{9.5-10}{2}\right) = P(Z < -0.25)$ M1 B1



$P(Z < -0.25) = 1 - P(0 < Z < 0.25)$ B1

$= 1 - 0.0987 = \underline{\underline{0.4013}}$ M1 A1

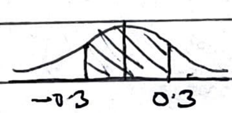
b) ~~$P(247 < W < 253) = P\left(\frac{247-10}{2} < W < \frac{253-10}{2}\right)$~~

$=$

$\frac{247}{25} = 9.88 \qquad \frac{253}{25} = 10.12$

b $P(9.88 < \bar{W} < 10.12) = P\left(\frac{9.88-10}{2/5} < Z < \frac{10.12-10}{2/5}\right)$ M1

$= P(-0.3 < Z < 0.3)$ B1



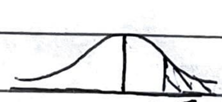
$P(-0.3 < Z < 0.3) = 2P(0 < Z < 0.3)$

$= 2(0.1179)$ M1

$= \underline{0.2358}$ M1

c) $P(\bar{W} > 10.2) = P\left(Z > \frac{10.2-10}{2/5}\right)$ M1

$= P(Z > 0.5)$ B1



$P(Z > 0.5) = 0.5 - P(0 < Z < 0.5)$

$= 0.5 - 0.1915$

$= 0.3085$ M1

16

a) Area under the curve

$$A = \int_0^2 y\,dx = \int_0^2 (8-x^2)\,dx$$

$$= \left[8x - \frac{x^3}{3}\right]_0^2 = \frac{40}{3}\ \text{cm}^2.$$

$$\frac{40}{3} \times W \times \bar{x} = \int_0^2 Wy \cdot x\,dx \qquad W \equiv \text{weight per unit area.}$$

$$\frac{40}{3}\bar{x} = \int_0^2 [8x - x^3]\,dx$$

$$\frac{40}{3}\bar{x} = \left[4x^2 - \frac{x^4}{4}\right]_0^2$$

$$\frac{40}{3}\bar{x} = 12$$

$$\bar{x} = \frac{9}{10}\ \text{cm}$$

b) :

lamina	Area (cm^2)	weight	C.O.G from y-axis
OADE	$\frac{40}{3}$	$\frac{40}{3}W$	$\frac{9}{10}$
ABCD	$5 \times 4 = 20$	$20W$	$\frac{9}{2}$
Composite Lamina	$\frac{100}{3}$	$\frac{100}{3}W$	$\bar{x}$

$$\frac{100}{3}W \times \bar{x} = \frac{40}{3}W \times \frac{9}{10} + 20W \times \frac{9}{2}$$

$$\frac{100}{3}\bar{x} = 12 + 90$$

$$\bar{x} = 3.06\ \text{cm}$$