A-LEVEL H2 MATH 2018 – PAPER 2

Question 1

[Ans: (i) $y=3\left(\frac{2}{9}x+4\right)^{\frac{3}{2}}+45$ (ii) $(54,237)$]

(i) $\frac{dy}{dx}=\left(\frac{1}{3}y-15\right)^{\frac{1}{3}}$

$\left(\frac{1}{3}y-15\right)^{-\frac{1}{3}}\frac{dy}{dx}=1$

$\int\left(\frac{1}{3}y-15\right)^{-\frac{1}{3}}dy=\int dx$

$\frac{\left(\frac{1}{3}y-15\right)^{\frac{2}{3}}}{\left(\frac{1}{3}\right)\left(\frac{2}{3}\right)}=x+A$

$\left(\frac{1}{3}y-15\right)^{\frac{2}{3}}=\frac{2}{9}x+B$

When $x=0$, $y=69$,

$\left[\frac{1}{3}(69)-15\right]^{\frac{2}{3}}=\frac{2}{9}(0)+B\Rightarrow B=4$

$\left(\frac{1}{3}y-15\right)^{\frac{2}{3}}=\frac{2}{9}x+4$

$\frac{1}{3}y-15=\left(\frac{2}{9}x+4\right)^{\frac{3}{2}}\Rightarrow y=3\left(\frac{2}{9}x+4\right)^{\frac{3}{2}}+45$

(ii) When $\frac{dy}{dx}=4$,

$\left(\frac{1}{3}y-15\right)^{\frac{1}{3}}=4\Rightarrow y=237$

$\therefore\left[\frac{1}{3}(237)-15\right]^{\frac{2}{3}}=\frac{2}{9}x+4\Rightarrow x=54$

$\therefore$ coordinates of the point on the curve where gradient is 4 is $(54,237)$.

Question 2

[Ans: (a) $x = 2-3i, 2+3i$ or $\frac{1}{2}$; $s = 69$, $t = 13$ (b)(i) $-\frac{3}{2}-\frac{3\sqrt{3}}{2}i$ and $-\frac{3}{2}+\frac{3\sqrt{3}}{2}i$

(ii) $w = 3e^{i(0)}$, $w = 3e^{-i\frac{2\pi}{3}}$ or $w = 3e^{i\frac{2\pi}{3}}$; sketch (iii) 0; 27]

(a) Let $f(x) = 4x^4 - 20x^3 + sx^2 - 56x + t$

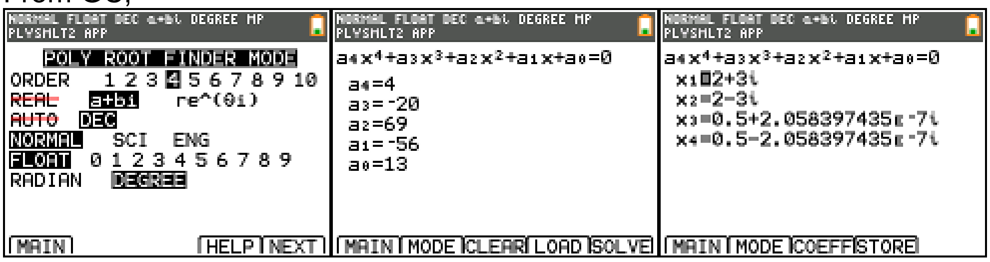
$$f(2-3i) = 0$$
$$4(2-3i)^4 - 20(2-3i)^3 + s(2-3i)^2 - 56(2-3i) + t = 0$$
$$332 + 828i + (-5-12i)s + t = 0$$
$$(332 - 5s + t) + i(828 - 12s) = 0$$

$$\therefore 828 - 12s = 0 \Rightarrow s = 69$$

$$\therefore 332 - 5(69) + t = 0 \Rightarrow t = 13$$

$$4x^4 - 20x^3 + 69x^2 - 56x + 13 = 0$$

From GC,



$x = 2-3i, 2+3i$ or $\frac{1}{2}$

(b) (i) Let $w = x + iy$

$$(x+iy)^3 = 27$$
$$x^3 + 3x^2(iy) + 3x(iy)^2 + (iy)^3 = 27$$
$$(x^3 - 3xy^2) + i(3x^2y - y^3) = 27$$
$$3x^2y - y^3 = 0$$
$$y(3x^2 - y^2) = 0$$
$$y(\sqrt{3}x + y)(\sqrt{3}x - y) = 0$$

$y = 0$ or $y = -\sqrt{3}x$ or $y = \sqrt{3}x$

When $y = 0$,

$$x^3 - 3x(0)^2 = 27$$
$$x^3 = 27 \Rightarrow x = 3$$

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When $y=\pm\sqrt{3}x$,

$$x^3-3x\left(\pm\sqrt{3}x\right)^2=27$$

$$x^3=-\frac{27}{8}\Rightarrow x=-\frac{3}{2}$$

$$\Rightarrow y=\pm\frac{3\sqrt{3}}{2}$$

$\therefore$ the other possible values of w are $-\frac{3}{2}-\frac{3\sqrt{3}}{2}i$ and $-\frac{3}{2}+\frac{3\sqrt{3}}{2}i$.

(ii) For $w=3$,

$$w=3e^{i(0)}$$

For $w=-\frac{3}{2}-\frac{3\sqrt{3}}{2}i$,

$$|w|=\sqrt{\left(-\frac{3}{2}\right)^2+\left(-\frac{3\sqrt{3}}{2}\right)^2}=3\text{; } \arg w=-\pi+\tan^{-1}\frac{3\sqrt{3}/2}{3/2}=-\frac{2\pi}{3}$$

$$\therefore w=3e^{-i\frac{2\pi}{3}}$$

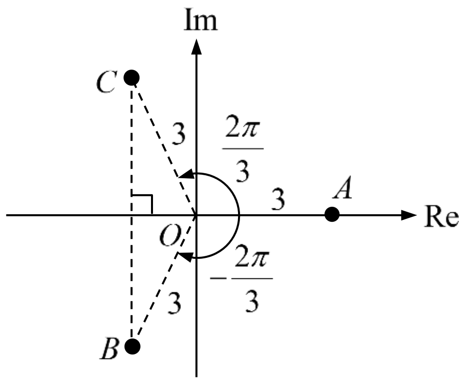
For $w=-\frac{3}{2}+\frac{3\sqrt{3}}{2}i$,

$$w=3e^{i\frac{2\pi}{3}}$$

$A:3e^{i(0)}$

$B:3e^{-i\frac{2\pi}{3}}$

$C:3e^{i\frac{2\pi}{3}}$



(iii) Sum

$$=3+\left(-\frac{3}{2}-\frac{3\sqrt{3}}{2}i\right)+\left(-\frac{3}{2}+\frac{3\sqrt{3}}{2}i\right)=0$$

Product

$$=\left[3e^{i(0)}\right]\left[3e^{-i\frac{2\pi}{3}}\right]\left[3e^{i\frac{2\pi}{3}}\right]=27e^{i\left(0-\frac{2\pi}{3}+\frac{2\pi}{3}\right)}=27e^{i(0)}=27$$

Question 3

[Ans: (i) $D(-5,-4,3)$ (ii) $4x+45y+20z=200$ (iii) $58.6°$ (iv) 6.88 units]

(i) $\overrightarrow{OD}$

$=\overrightarrow{OA}+\overrightarrow{AD}$

$=\overrightarrow{OA}+\overrightarrow{BC}=\overrightarrow{OA}+\left(\overrightarrow{OC}-\overrightarrow{OB}\right)=\begin{pmatrix}5\\-4\\1\end{pmatrix}+\left[\begin{pmatrix}-5\\4\\2\end{pmatrix}-\begin{pmatrix}5\\4\\0\end{pmatrix}\right]=\begin{pmatrix}-5\\-4\\3\end{pmatrix}$

$\therefore D(-5,-4,3)$

(ii) $\overrightarrow{BC}=\begin{pmatrix}-5\\4\\2\end{pmatrix}-\begin{pmatrix}5\\4\\0\end{pmatrix}=\begin{pmatrix}-10\\0\\2\end{pmatrix}$; $\overrightarrow{BE}=\begin{pmatrix}0\\0\\10\end{pmatrix}-\begin{pmatrix}5\\4\\0\end{pmatrix}=\begin{pmatrix}-5\\-4\\10\end{pmatrix}$

$\begin{pmatrix}-10\\0\\2\end{pmatrix}\times\begin{pmatrix}-5\\-4\\10\end{pmatrix}=\begin{pmatrix}8\\90\\40\end{pmatrix}=2\begin{pmatrix}4\\45\\20\end{pmatrix}$

Face $BCE: \underset{\sim}{r}\cdot\begin{pmatrix}4\\45\\20\end{pmatrix}=\begin{pmatrix}0\\0\\10\end{pmatrix}\cdot\begin{pmatrix}4\\45\\20\end{pmatrix}=200$

$\therefore$ cartesian equation of face BCE is $4x+45y+20z=200$.

(iii) $\overrightarrow{AB}=\begin{pmatrix}5\\4\\0\end{pmatrix}-\begin{pmatrix}5\\-4\\1\end{pmatrix}=\begin{pmatrix}0\\8\\-1\end{pmatrix}$; $\overrightarrow{AD}=\begin{pmatrix}-5\\-4\\3\end{pmatrix}-\begin{pmatrix}5\\-4\\1\end{pmatrix}=\begin{pmatrix}-10\\0\\2\end{pmatrix}$

$\begin{pmatrix}0\\8\\-1\end{pmatrix}\times\begin{pmatrix}-10\\0\\2\end{pmatrix}=\begin{pmatrix}16\\10\\80\end{pmatrix}=2\begin{pmatrix}8\\5\\40\end{pmatrix}$

Let the angle between face BCE and the base of the pyramid be θ.

$\begin{pmatrix}8\\5\\40\end{pmatrix}\cdot\begin{pmatrix}4\\45\\20\end{pmatrix}=\left|\begin{pmatrix}8\\5\\40\end{pmatrix}\right|\left|\begin{pmatrix}4\\45\\20\end{pmatrix}\right|\cos\theta$

$1057=\sqrt{1689}\sqrt{2441}\cos\theta$

$\cos\theta=\dfrac{1057}{\sqrt{1689}\sqrt{2441}}\Rightarrow\theta=58.6°$

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(iv) Let M be the midpoint of edge AD.

$$\overrightarrow{OM} = \frac{(1)OA+(1)OD}{1+1} = \frac{1}{2}\left[\begin{pmatrix}5\\-4\\1\end{pmatrix}+\begin{pmatrix}-5\\-4\\3\end{pmatrix}\right] = \begin{pmatrix}0\\-4\\2\end{pmatrix}$$

Shortest distance

$$= \left|\frac{\begin{pmatrix}0\\-4\\2\end{pmatrix}\cdot\begin{pmatrix}4\\45\\20\end{pmatrix}}{\left|\begin{pmatrix}4\\45\\20\end{pmatrix}\right|} - \frac{200}{\left|\begin{pmatrix}4\\45\\20\end{pmatrix}\right|}\right| = \left|\frac{-140}{\sqrt{2441}} - \frac{200}{\sqrt{2441}}\right| = 6.88$$

Question 4

[Ans: (i) $-2x^2-\frac{4}{3}x^4-\frac{64}{45}x^6$; $x=\frac{1}{4}\pi$ (ii) $-2x-\frac{4}{3}x^3-\frac{64}{225}x^5+c$; -1.0644 (iii) -1.0670]

(i) $\ln(\cos 2x)$

$$=\ln\left[1-\frac{(2x)^2}{2!}+\frac{(2x)^4}{4!}-\frac{(2x)^6}{6!}+\dots\right]$$

$$=\ln\left(1-2x^2+\frac{2}{3}x^4-\frac{4}{45}x^6+\dots\right)$$

$$=\ln\left[1+\left(-2x^2+\frac{2}{3}x^4-\frac{4}{45}x^6+\dots\right)\right]$$

$$\approx\left(-2x^2+\frac{2}{3}x^4-\frac{4}{45}x^6\right)-\frac{\left(-2x^2+\frac{2}{3}x^4-\frac{4}{45}x^6\right)^2}{2}+\frac{\left(-2x^2+\frac{2}{3}x^4-\frac{4}{45}x^6\right)^3}{3}$$

$$=\left(-2x^2+\frac{2}{3}x^4-\frac{4}{45}x^6\right)-\frac{1}{2}\left(4x^4-\frac{4}{3}x^6-\frac{4}{3}x^6\right)+\frac{1}{3}\left(-8x^6\right)$$

$$=-2x^2-\frac{4}{3}x^4-\frac{64}{45}x^6$$

For $0\le x\le\frac{1}{4}\pi$, $0\le\cos 2x\le 1$. $\therefore$ the expansion will be undefined when $\cos 2x=0$ as $\ln 0$ is undefined.

$$\therefore \cos 2x=0\Rightarrow 2x=\frac{1}{2}\pi\Rightarrow x=\frac{1}{4}\pi$$

(ii) $\int\frac{\ln(\cos 2x)}{x^2}\,dx$

$$\approx\int\frac{-2x^2-\frac{4}{3}x^4-\frac{64}{45}x^6}{x^2}\,dx$$

$$=\int -2-\frac{4}{3}x^2-\frac{64}{45}x^4\,dx$$

$$=-2x-\frac{4}{9}x^3-\frac{64}{225}x^5+c$$

$$\int_0^{0.5}\frac{\ln(\cos 2x)}{x^2}\,dx=\left[-2x-\frac{4}{9}x^3-\frac{64}{225}x^5\right]_0^{0.5}$$

$$=-1.0644$$

(iii) From GC, $\int_0^{0.5}\frac{\ln(\cos 2x)}{x^2}\,dx=-1.0670$

Queston 5

[Ans: (i) explain; state (ii) $H_0 : \mu = 65000$; $H_1 : \mu < 65000$ (iii) $\sigma^2 > 9420000$]

(i) As we do not know if the time to failure of the fan follows a normal distribution, in order to apply the Central Limit Theorem to assume the sample mean distribution of the time to failure of the fan follows a normal distribution, the sample size should be reasonably large. Therefore the manager should take a sample of at least 30 fans.

The fans should be randomly chosen.

(ii) Let X be the time to failure of the fan, and μ be the population mean of X.

$H_0 : \mu = 65000$

$H_1 : \mu < 65000$

(iii) $n = 43$

$\bar{x} = 64230$

Let σ^2 be the population variance.

Test Statistics,

$n = 43$ (large)

$\bar{X} \sim N\left(65000, \frac{\sigma^2}{43}\right)$ by CLT

$$\Rightarrow Z = \frac{\bar{X} - 65000}{\sqrt{\frac{\sigma^2}{43}}} \sim N(0,1)$$

To not reject H_0,

p-value > 0.05

$$P(\bar{X} < 64230) > 0.05$$

$$P\left(Z < \frac{64230 - 65000}{\sqrt{\frac{\sigma^2}{43}}}\right) > 0.05$$

$$\frac{64230 - 65000}{\sqrt{\frac{\sigma^2}{43}}} > -1.6449$$

$$\frac{64230 - 65000}{-1.6449} < \sqrt{\frac{\sigma^2}{43}}$$

$$\sqrt{\sigma^2} > \frac{64230 - 65000}{-1.6449}\sqrt{43}$$

$$\sigma^2 > 9420000$$

Question 6

[Ans: (i) show (ii) $\frac{5}{9} < p < \frac{2}{3}$ (iii) 0.430]

(i) Let X be the number of left fork that the bug takes out of 8 forks.

$X \sim B(8, p)$

Probability for the bug to finish at D

$= P(X = 5)$

$= \binom{8}{5} p^5 (1-p)^{8-5} = 56p^5q^3$ (shown)

(ii) Given $P(X = 5)$ is the highest probability.

$P(X = 5) > P(X = 4)$ and $P(X = 5) > P(X = 6)$

$56p^5q^3 > \binom{8}{4} p^4q^4$

$56p > 70q$

$56p > 70(1-p)$

$126p > 70$

$p > \frac{5}{9}$

$56p^5q^3 > \binom{8}{6} p^6q^2$

$56q > 28p$

$56(1-p) > 28p$

$84p < 56$

$p < \frac{2}{3}$

$\therefore \frac{5}{9} < p < \frac{2}{3}$

(iii) Required probability

$= (1-0.1)^8$

$= 0.430$

Question 7

[Ans: (i) $(1-a)(1-b)$; prove (ii) $1-a-c$; draw (iii)]

(i) $P(A'\cap B')$

$=1-P(A\cup B)$

$=1-\left[P(A)+P(B)-P(A\cap B)\right]$

$=1-\left[P(A)+P(B)-P(A)P(B)\right]$

$=1-(a+b-ab)$

$=1-a-b+ab$

$=(1-a)-b(1-a)=(1-a)(1-b)$

$P(A'\cap B')=(1-a)(1-b)=P(A')P(B')$

$\therefore A'$ and B' are independent events. (proven)

(ii) $P(A'\cap C')$

$=1-P(A\cup C)$

$=1-\left[P(A)+P(C)-P(A\cap C)\right]$

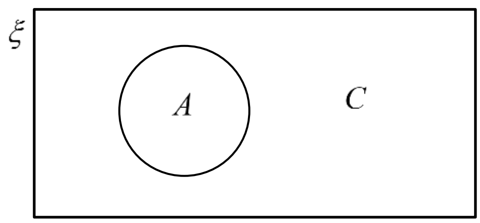
$=1-(a+c-0)=1-a-c$

If A' and C' are mutually exclusive events,

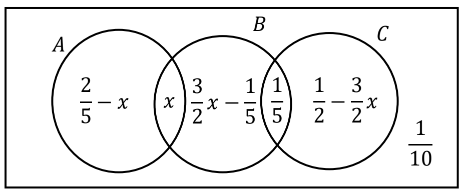
$P(A'\cap C')=0$

$1-a-c=0$

$a+c=1$



(iii) Let $P(A\cap B)=x$.



$P(A)P(B)=x\Rightarrow \frac{2}{5}P(B)=x\Rightarrow P(B)=\frac{5}{2}x$

$P(A\cap B'\cap C')=\frac{2}{5}-x$

$P(A'\cap B\cap C')=P(B)-x-\frac{1}{5}=\frac{5}{2}x-x-\frac{1}{5}=\frac{3}{2}x-\frac{1}{5}$

$P(A'\cap B'\cap C)=1-\frac{1}{10}-\left(\frac{2}{5}-x\right)-x-\left(\frac{3}{2}x-\frac{1}{5}\right)-\frac{1}{5}=\frac{1}{2}-\frac{3}{2}x$

$$\left.\begin{array}{l} 0\le x\le 1 \\ 0\le \frac{2}{5}-x\le 1\Rightarrow -\frac{3}{5}\le x\le \frac{2}{5} \\ 0\le \frac{3}{2}x-\frac{1}{5}\le 1\Rightarrow \frac{2}{15}\le x\le \frac{4}{5} \\ 0\le \frac{1}{2}-\frac{3}{2}x\le 1\Rightarrow -\frac{1}{3}\le x\le \frac{1}{3} \end{array}\right\} \therefore \frac{2}{15}\le x\le \frac{1}{3}$$

Maximum and minimum possible values of $P(A\cap B)$ are $\frac{1}{3}$ and $\frac{2}{15}$ respectively.

Question 8

[Ans: (i) probability distribution (ii) 0 ; explain (iii) show; $g(n)=22n^2+78n+36$]

(i)

	3	4	5
3	6	7	8
4	7	8	9
5	8	9	10

$$P(S=6)=\left(\frac{2}{n+5}\right)\left(\frac{1}{n+4}\right)=\frac{2}{(n+5)(n+4)}$$

$$P(S=7)=\left(\frac{2}{n+5}\right)\left(\frac{3}{n+4}\right)+\left(\frac{3}{n+5}\right)\left(\frac{2}{n+4}\right)=\frac{12}{(n+5)(n+4)}$$

$$P(S=8)=\left(\frac{2}{n+5}\right)\left(\frac{n}{n+4}\right)+\left(\frac{3}{n+5}\right)\left(\frac{2}{n+4}\right)+\left(\frac{n}{n+5}\right)\left(\frac{2}{n+4}\right)=\frac{4n+6}{(n+5)(n+4)}$$

$$P(S=9)=\left(\frac{3}{n+5}\right)\left(\frac{n}{n+4}\right)+\left(\frac{n}{n+5}\right)\left(\frac{3}{n+4}\right)=\frac{6n}{(n+5)(n+4)}$$

$$P(S=10)=\left(\frac{n}{n+5}\right)\left(\frac{n-1}{n+4}\right)=\frac{n(n-1)}{(n+5)(n+4)}$$

s	6	7	8	9	10
$P(S=s)$	$\frac{2}{(n+5)(n+4)}$	$\frac{12}{(n+5)(n+4)}$	$\frac{4n+6}{(n+5)(n+4)}$	$\frac{6n}{(n+5)(n+4)}$	$\frac{n(n-1)}{(n+5)(n+4)}$

(ii) When $n=1$, $P(S=10)=\dfrac{(1)(1-1)}{(1+5)(1+4)}=0$

As there needs to be two balls numbered 5 in order to get sum of the numbers on the two balls taken to be 10, it is impossible for S to be 10 since now there is just 1 ball numbered 5. Therefore $P(S=10)=0$ is expected.

(iii) $E(S)$

$$=\sum sP(S=s)$$

$$=6\left[\frac{2}{(n+5)(n+4)}\right]+7\left[\frac{12}{(n+5)(n+4)}\right]+8\left[\frac{4n+6}{(n+5)(n+4)}\right]+9\left[\frac{6n}{(n+5)(n+4)}\right]$$

$$+10\left[\frac{n(n-1)}{(n+5)(n+4)}\right]$$

$$=\frac{12+84+32n+48+54n+10n^2-10n}{(n+5)(n+4)}$$

$$=\frac{10n^2+76n+144}{(n+5)(n+4)}$$

$$=\frac{(10n+36)(n+4)}{(n+5)(n+4)}=\frac{10n+36}{n+5}$$ (shown)

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$E\left(S^2\right)$

$=\sum s^2 P\left(S=s\right)$

$=6^2\left[\frac{2}{(n+5)(n+4)}\right]+7^2\left[\frac{12}{(n+5)(n+4)}\right]+8^2\left[\frac{4n+6}{(n+5)(n+4)}\right]+9^2\left[\frac{6n}{(n+5)(n+4)}\right]$

$+10^2\left[\frac{n(n-1)}{(n+5)(n+4)}\right]$

$=\frac{72+588+256n+384+486n+100n^2-100n}{(n+5)(n+4)}$

$=\frac{100n^2+642n+1044}{(n+5)(n+4)}$

$Var\left(S\right)$

$=E\left(S^2\right)-\left[E\left(S\right)\right]^2$

$=\frac{100n^2+642n+1044}{(n+5)(n+4)}-\left(\frac{10n+36}{n+5}\right)^2$

$=\frac{\left(100n^2+642n+1044\right)(n+5)-(10n+36)^2(n+4)}{(n+5)^2(n+4)}$

$=\frac{\left(100n^2+642n+1044\right)(n+5)-\left(100n^2+720n+1296\right)(n+4)}{(n+5)^2(n+4)}$

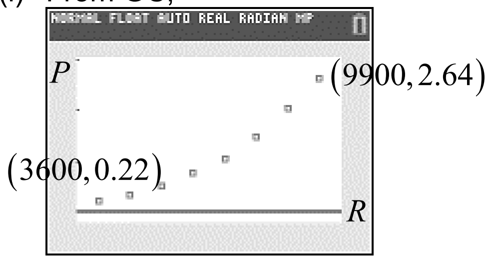
$=\frac{22n^2+78n+36}{(n+5)^2(n+4)}$

$\therefore g\left(n\right)=22n^2+78n+36$

Question 9

[Ans: (i) draw; explain (ii) $r = 0.969$; $r = 0.993$; explain; $P = 2.85\times10^{-8}R^2 - 0.283$
(iii) $R = 6450$; explain (iv) $P = 0.0273$; explain (v) $P = 1.03\times10^{-4}R^2 - 0.283$]

(i) From GC,



The scatter diagram suggests that the relationship between P and R is non-linear, where P increases at an increasing rate as R increases. Therefore it will not be well modelled by the linear equation $P = aR + b$.

(ii) For model $P = aR + b$,

$r = 0.969$

For model $P = aR^2 + b$,

$r = 0.993$

Since $|r|$ for model $P = aR^2 + b$ is closer to 1, it will better model the relationship between P and R.

From GC, equation: $P = 2.85\times10^{-8}R^2 - 0.283$

(iii) When $P = 0.9$,

$0.9 = 2.8457\times10^{-8}R^2 - 0.28261$

$R = 6450$

As $P = 0.9$ is within the data range, $0.22 \le P \le 2.64$, and r is very close to 1, the estimate is reliable.

(iv) When $R = 3300$,

$P = 2.8457\times10^{-8}(3300)^2 - 0.28261$

$= 0.0273$

As $R = 3300$ is outside the data range, $3600 \le R \le 9900$, the estimate is unreliable.

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(v) Given R is the speed of the fan in revolution per second.
Let R_m be speed of the fan in revolution per minute.

$P = 2.8457 \times 10^{-8} R_m{}^2 - 0.28261$ and $R_m = 60R$

$$P = 2.8457 \times 10^{-8} \left(60R\right)^2 - 0.28261$$
$$= 1.03 \times 10^{-4} R^2 - 0.283$$

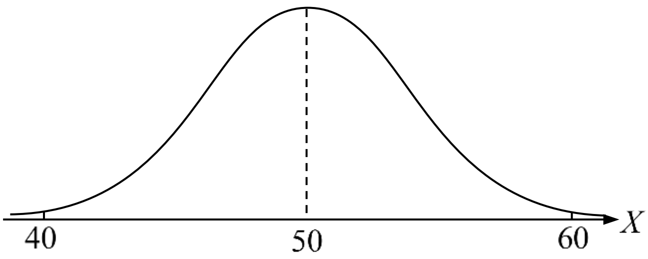
Question 10

[Ans: (i) sketch (ii) 0.605 (iii) 0.773 (iv) 0.126 (v) 136 (vi) 0.185]

Let X be the mass of one type of specialist light bulb.

$X \sim N\left(50, 1.5^2\right)$

(i)



(ii) $P\left(X < 50.4\right) = 0.605$

(iii) Let Y be the mass of an empty box.

$Y \sim N\left(75, 2^2\right)$

$E\left(Y_1 + \ldots + Y_4\right) = 4E\left(Y\right) = 4\left(75\right) = 300$

$Var\left(Y_1 + \ldots + Y_4\right) = 4Var\left(Y\right) = 4\left(2^2\right) = 16$

$\therefore Y_1 + \ldots Y_4 \sim N\left(300, 16\right)$

$P\left(Y_1 + \ldots + Y_4 > 297\right) = 0.773$

(iv) $E\left(X + Y\right) = E\left(X\right) + E\left(Y\right) = 50 + 75 = 125$

$Var\left(X + Y\right) = Var\left(X\right) + Var\left(Y\right) = 1.5^2 + 2^2 = 6.25$

$\therefore X + Y \sim N\left(125, 6.25\right)$

$P\left(124.9 < X + Y < 125.7\right) = 0.126$

(v) $E\left(1.3X + Y\right) = 1.3E\left(X\right) + E\left(Y\right) = 1.3\left(50\right) + 75 = 140$

$Var\left(1.3X + Y\right) = 1.3^2 Var\left(X\right) + Var\left(Y\right) = 1.3^2\left(1.5^2\right) + 2^2 = 7.8025$

$\therefore 1.3X + Y \sim N\left(140, 7.8025\right)$

$P\left(1.3X + Y > k\right) = 0.9$

$k = 136$

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(vi) Let W be the mass of a box containing a bulb with it padding.

$W = 1.3X + Y \sim N(140, 7.8025)$

$E(W_1 + \ldots W_4) = 4E(W) = 4(140) = 560$

$Var(W_1 + \ldots W_4) = 4Var(W) = 4(7.8025) = 31.21$

$W_1 + \ldots W_4 \sim N(560, 31.21)$

$P(W_1 + \ldots W_4 > 565) = 0.185$