MATHEMATICS II

Date: 20/06/2024
Period: 08.30 – 11.30

NESA NATIONAL EXAMINATION AND SCHOOL INSPECTION AUTHORITY

END OF TERM III EXAMINATIONS QUESTION PAPER

GRADE: **SENIOR FIVE**

COMBINATIONS: MATHEMATICS-CHEMISTRY-BIOLOGY **(MCB)**

- MATHEMATICS -COMPUTER SCIENCE-ECONOMICS **(MCE)**
- MATHEMATICS-ECONOMICS-GEOGRAPHY **(MEG)**
- MATHEMATICS -PHYSICS-COMPUTER SCIENCE **(MPC)**
- MATHEMATICS-PHYSICS-GEOGRAPHY **(MPG)**
- PHYSICS-CHEMISTRY-MATHEMATICS **(PCM)**

DURATION: **3 HOURS**

MARKS: **100** **CAMIS** **……/70**

INSTRUCTIONS

1) This paper contains **two** sections:

Section A: Attempt **all** questions. **(55 marks)**

Section B: Attempt **three** questions only. **(45 marks)**

2) You may use mathematical instruments and a calculator **where necessary.**

3) Use a **blue or black ink pen only** to write your answers and a **pencil** to draw diagrams.

4) Show clearly all the working steps. **Marks will not be awarded for the answer without all working steps.**

Section A: Attempt all questions (55 marks)

1. Show that $\cos 3A = 4\cos^3 A - 3\cos A$ **(4 marks)**

2. If $\sin A = \frac{3}{5},\quad 0 < A < \frac{\pi}{2}$ and $\sin B = \frac{4}{5},\ \frac{\pi}{2} < B$ $< \pi$ Evaluate $\cos(A+B)$ without the use of a calculator. **(4 marks)**

3. Solve the trigonometric equation $2\sin\frac{x}{2} - \cos x + 1 = 1$ **(5 marks)**

4. Show that $U_n=\{3(-2)^n\}$ is a geometric sequence and write down the first 4 terms of this sequence. **(3 marks)**

5. The population of a country grow according to the law $p = Ae^{0.06t}$, where p is million in the population at time t and A is a constant given that t=0 the population is 27.3 millions

   Calculate the population when :

   i. t=10 **(2 marks)**

   ii. t=15 **(2 marks)**

6. Fill in blanks $y = sin^{-1}x$ means that $x = ...$ where $-1 \le x \le 1$ and $-\frac{\pi}{2} \le y \le \frac{\pi}{2}$ **(2 marks)**

7. Calculate $\lim_{x\to 0}\frac{\sin 8x}{\sin 5x}$ **(3 marks)**

8. Study the parity of the function $f(x) = \frac{x + \sin 3x}{x^2}$ **(4 marks)**

9. Answer by **True** or **False.** Two vectors are parallel if:

   a) They have the opposite directions **(1 mark)**

   b) They have the same magnitude **(1 mark)**

   c) They lie in the same plane **(1 mark)**

10. a) Show that $B = \{\vec{u}, \vec{v}, \vec{w}\}$ where $\vec{u} = (1,-1,2), \vec{v} = (1,1,1), \vec{w} = (-1,0,1)$ is a basis of $\mathbb{R}$. **(2 marks)**

    b) Find the components of the vector $\vec{t} = (0,-3,4)$ in the basis B

    (2 marks)

11. Without calculating explain why $\Delta = \begin{vmatrix} 1 & 5 & -2 \\ 2 & 10 & -4 \\ 3 & 1 & 5 \end{vmatrix} = 0$ **(2 marks)**

12. Given A and B matrices representation of linear transformation f and g respectively such that

$$A = \begin{pmatrix} 3 & 4 & 1 \\ -1 & 2 & 0 \\ 4 & -5 & -3 \end{pmatrix} \text{and } B = \begin{pmatrix} 2 & 3 & 2 \\ -1 & 0 & 3 \\ 1 & 0 & 2 \end{pmatrix}.$$

Find the matrix representation of gof . **(3 marks)**

13.Find the centre and the radius of the Sphere

$S \equiv x^2 + y^2 + z^2 + 4x - 8y + 6z - 7 = 0$

(4 marks)

14. Find the Cartesian equation of the plane α through the points $a(3,2,-1)$; $b(4,4,0)$ and perpendicular to the plane $\beta \equiv 2x + 4y - 4z = 3$

(5 marks)

15. Find the vector position of the point of intersection of the lines

$$L_1 \equiv \begin{cases} X = 3 + 3t \\ y = 3 + 2t \\ z = t \end{cases} \text{ and } L_2 \equiv \begin{cases} X = 4 + s \\ y = 3 + s \\ z = -1 + s \end{cases}$$ **(5 marks)**

Section B: Attempt any three questions only (45 marks).

16. The first 3 terms of an arithmetic series are k-2, 2k+5 and 4k+1.

a) Show that k=11 **(3 marks)**
b) Find the 41th term of the series **(7 marks)**
c) Show that S_n is always a square number **(5 marks)**

17. Using the iterative formula, show that the 4th root of the number N is $x_{n+1} = \frac{3}{4}x_n + \frac{N}{4x^3_n}$.Hence show that $(45.7)^{1/4} \approx 2.600$ (correct to 3dps) **(15 marks)**

18. If $A = \begin{pmatrix} \cos A & -\sin A & 0 \\ \sin A & \cos A & 0 \\ 0 & 0 & 1 \end{pmatrix}$ verify that $A \cdot (Adj) = \det(A) \cdot I$ **(15 marks)**

19. Let consider the following table

x_i	-5	-1	3	10	13
y_i	33	25	17	3	-3

i) Calculate the coefficient of correlation and comment on it. **(8 marks)**

ii) Find the equation of regression line y on x. **(5 marks)**

Iii) Estimate the value of x when $y = 16$. **(2 marks)**

20. a) If A and B are dependent events such that $p(A) = \frac{5}{8}$ and $p(B/A) = \frac{3}{7}$

Find $p(A \cap B)$ **(5 marks)**

b) 3 girls A, B, and C pack biscuit in a factory from the batch allocated to them A packs 55%, B packs 30% and C packs 15%. The probability that A break some biscuits in packet is 0.7 and the respective probability of B is 0.2 and C is 0.1. What is the probability that a packet with broken biscuits found by checker was packed by A. **(10 marks)**

END!!!!!

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END OF TERM III EXAMINATIONS MARKING GUIDE

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SECTION A: ATTEMPT ALL QUESTIONS (55 MARKS)

1. $\cos 3A = 4\cos^3 A - 3\cos A$

We know that:

$\cos 3A = \cos(2A + A)$ 0.5

$= \cos 2A\cos A - \sin 2A\sin A$ 1

$= (\cos^2 A - \sin^2 A)\cos A - 2\sin^2 A\cos A$ 0.5

$= (\cos^2 A - (1-\cos^2 A))\cos A - 2(1-\cos^2 A)\cos A$ 0.5

$= (\cos^2 A - 1 + \cos^2 A)\cos A - 2(1-\cos^2 A)\cos A$ 0.5

$= \cos^3 A - \cos A + \cos^3 A - 2\cos A + 2\cos^3 A$ 0.5

$= 4\cos^3 A - 3\cos A$ as required 0.5

2. $\sin A = \frac{3}{5} \quad 0 < A < \frac{\pi}{2}$

$\sin B = \frac{4}{5} \quad \frac{\pi}{2} < B < \pi$

$\cos(A+B) = \cos A\cos B - \sin A\sin B$ 1

$\cos A = \pm\sqrt{1-\sin^2 A} = \pm\sqrt{1-\frac{9}{25}} = \frac{4}{5}, \quad 0 < A < \frac{\pi}{2}$ 1

$\cos B = \pm\sqrt{1-\sin^2 B} = \pm\sqrt{1-\frac{16}{25}} = -\frac{3}{5}, \quad \frac{\pi}{2} < B < \pi$ 1

Thus

$\cos A\cos B - \sin A\sin B = \frac{4}{5}\left(-\frac{3}{5}\right) - \frac{3}{5}\left(\frac{4}{5}\right)$ 0.5

$= -\frac{24}{25}$ 0.5

3. $2\sin^2\frac{x}{2} - \cos x + 1 = 1$

$$2\sin^2\frac{x}{2}+(1-\cos x)=1 \text{ .... } 0.5$$

$$2\sin^2\frac{x}{2}+2\sin^2\frac{x}{2}=1 \text{ .... } 0.5$$

$$4\sin^2\frac{x}{2}=1 \text{ .... } 0.5$$

$$\sin^2\frac{x}{2}=\frac{1}{4}$$

$$\Rightarrow \sin\frac{x}{2}=\pm\frac{1}{2} \text{ .... } 0.5$$

For $\sin\frac{x}{2}=\frac{1}{2}$

$$\frac{x}{2}=\begin{cases}\frac{\pi}{6}+2k\pi\\ \frac{5\pi}{6}+2k\pi\end{cases} \quad 0.5\Rightarrow x=\begin{cases}\frac{\pi}{3}+4k\pi\\ \frac{5\pi}{3}+4k\pi\end{cases}, k\in\mathbb{Z} \text{ .... } 1$$

For $\sin\frac{x}{2}=-\frac{1}{2}$

$$\frac{x}{2}=\begin{cases}\frac{4\pi}{3}+2k\pi\\ \frac{5\pi}{3}+2k\pi\end{cases} \quad 0.5\Rightarrow x=\begin{cases}\frac{8\pi}{3}+4k\pi\\ \frac{10\pi}{3}+4k\pi\end{cases}, k\in\mathbb{Z} \text{ .... } 1$$

$$\mathbb{S}=\left\{\frac{\pi}{3}+4k\pi,\quad \frac{5\pi}{3}+4k\pi,\quad \frac{8\pi}{3}+4k\pi,\quad \frac{10\pi}{3}+4k\pi\right\} \text{ .... } 1$$

4. $u_n=\{3(-2)^n\}$

$$u_{n+1}=3(-2)^{n+1} \text{ .... } 1$$

$$\frac{u_{n+1}}{u_n}=\frac{3(-2)^{n+1}}{3(-2)^n}$$

.... 1

$$=\frac{-2(-2)^n}{(-2)^n} \text{ .... } 0.5$$

$$=-2 \text{ .... } 0.5$$

5. i. $p = Ae^{0.06t}$ 0.5

$p(t=0) = Ae^{0.06\times 0} = 27.3$ 0.5

$\Rightarrow A = 27.3$ Then $p = 27.3e^{0.06t}$ 0.5

for t=10, $p = 27.3e^{0.06\times 10} = 49.7$ millions 0.5

ii. for t=15,$p = 27.3e^{0.06\times 15} = 67.1$ millions 2

6. $x = \sin y$ 2

7. $\lim\limits_{x\to 0}\frac{\sin 8x}{\sin 5x} = \frac{8}{5}\lim\limits_{x\to 0}\frac{5x\sin 8x}{8x\sin 5x}$ 1

$= \lim\limits_{x\to 0}\frac{\sin 8x}{8x}\bullet\lim\limits_{x\to 0}\frac{5x}{\sin 5x}$ 1

$= \frac{8}{5}$ 1

8. $Domf = \mathbb{R}\setminus\{0\}$ 0.5

$\forall x \in Domf \Rightarrow -x \in Domf$ 0.5

$f(-x) = \frac{-(x) + \sin 3(-x)}{(-x)^2}$ 0.5

$= \frac{-x - \sin 3x}{x^2}$ 1

$=- \frac{x + \sin 3x}{x^2} = -f(x)$ 0.5

Thus $f(x)$ is an odd function 1

9. a) True 1

b) False 1

c) False 1

10. a) Since $\dim\mathbb{R}^3 = 3$, to show that 3 vectors form a basis it is sufficient to

show that the 3 vectors are linearly independent 0.5

$$\det\left(\vec{u},\vec{v},\vec{w}\right)=\begin{vmatrix}1 & 1 & -1\\ -1 & 1 & 0\\ 2 & 1 & 1\end{vmatrix}=1+2+2=5\neq 0$$ 0.5

Therefore $\vec{u},\vec{v},\vec{w}$ are linearly $(0,-3,4)=x(1,-1,2)+y(1,1,1)+z(-1,0,1)$

independent ,hence they form a basis of $\mathbb{R}^3$ 1

b) $R_2=2R_1$ Let $\vec{t}=x\vec{u}+y\vec{v}+z\vec{w}\Leftrightarrow(0,-3,4)=x(1,-1,2)+y(1,1,1)+z(-1,0,1)$

$$\begin{cases}x+y-z=0\\ -x+y=-3\\ 2x+y+z=4\end{cases}\Leftrightarrow x=2, y=-1, z=1$$ 1

The components of $\vec{t}$ are $\begin{pmatrix}1\\ -1\\ 2\end{pmatrix}$ in the basis B 1

11. As the second row is twice the first row i.e $R_2=2R_1$ then $\Delta=0$.....................2

$$12.\ gof=\begin{pmatrix}2 & 3 & 2\\ -1 & 0 & 3\\ 1 & 0 & 2\end{pmatrix}\begin{pmatrix}3 & 4 & 1\\ -1 & 2 & 0\\ 4 & -5 & -3\end{pmatrix}$$ 1

$$=\begin{pmatrix}6-3+8 & 8+6-10 & 2+0-6\\ -3+0+12 & -4+0-15 & -1+0-9\\ 3+0+8 & 4+0-10 & 1+0-6\end{pmatrix}$$ 1

$$=\begin{pmatrix}11 & 4 & -4\\ 9 & -19 & -10\\ 11 & -6 & -5\end{pmatrix}$$ 1

13. $S\equiv x^2+y^2+z^2+4x-8y+6z-7=0$

$\equiv x^2+4x+y^2-8y+z^2+6z-7=0$ 1

$\equiv (x+2)^2+(y-4)^2+(z+3)^2-4-16-9-7=0$ 1

$\equiv (x+2)^2+(y-4)^2+(z+3)^2=36$ 1

Hence this is a circle with center $C(-2,4,-3)$ and Radius $R=6$ 1

14. Given that $a(3,2,-1),\ b(4,4,0),\ B\equiv 2x+4y-4z=3$

$\overrightarrow{ab}=(1,2,1)$

.... 0.5

$B^{\perp}=(2,4,-4)$ 0.5

$\alpha=(a,\overrightarrow{ab},B^{\perp})$ 1

$$\alpha\equiv\begin{vmatrix} x-3 & 1 & 2 \\ y-2 & 2 & 4 \\ z+1 & 1 & -4 \end{vmatrix}=0$$ 1

$\alpha\equiv -12(x-3)+6(y-2)+0(z+1)=0$ 1

$\alpha\equiv -12x+36+6y-12+0z=0$ 0.5

$\alpha\equiv 2x-y-12=0$ 0.5

15. $$L_1\cap L_2=\begin{cases}3+3t=4+\lambda\\ 3+2t=3+\lambda\\ t=-1+\lambda\end{cases}\Rightarrow\begin{cases}3t-\lambda=1\\ 2t-\lambda=0\\ t-\lambda=-1\end{cases}$$ 1

$$\begin{cases}3t-\lambda=1\\ 2t-\lambda=0\end{cases}\ \begin{vmatrix}1\\ -1\end{vmatrix}\Rightarrow\begin{cases}t=1\\ \lambda=2\end{cases}$$ 1

for $t=1,\ x=6,\ y=5,\ z=1$ 1

$L_1\cap L_2=\{(6,5,1)\}$ 1

Vector position $\vec{V}=6\vec{i}+5\vec{j}+\vec{k}$ 1

SECTION B: ATTEMPT ANY THREE QUESTIONS ONLY (45 MARKS)

16. Given that $k - 2$, $2k+5$ and $4k+1$ are terms of an a.s

a) $2k+5=\frac{k-2+4k+1}{2}$ 1

$\Leftrightarrow 4k+10=5k-1$ 1

$\Leftrightarrow 5k-4k=11$ 0.5

Hence k=11 as required 0.5

b) $u_n=u_1+(n-1)d$ 1

$u_1=11-2=9$ 1

$u_2=2(11)+5=27$ 1

$u_3=4(11)+1=45$ 1

The common difference d=18 1

$u_{41}=u_1+40d$ 1

= 9+40(18)=729 1

c) $S_n=\frac{n}{2}(u_1+u_n)$

$=\frac{n}{2}(u_1+u_1+(n-1)d)$ 1

$=\frac{n}{2}(2u_1+(n-1)d)$ 1

$=nu_1+\frac{n(n-1)}{2}d$ 0.5

$= 9n + \frac{n(n-1)}{2}18$ 0.5

$= 9n + 9n^2 - 9n$ 0.5

$= 9n^2$ 0.5

$= (3n)^2$ which is always square. 1

17. Using Newton Raphson method:

let $X = \sqrt[4]{N}$ 1

$\Rightarrow X^4 = N$ 0.5

$X^4 - N = 0$ 1

$\Rightarrow f(X) = X^4 - N$ 1

$X_{n+1} = X_n - \frac{f(X_n)}{f'(X_n)}$ for $n \in \mathbb{N}$ 1

$f'(X) = 4X^3$ 1

$X_{n+1} = X_n - \left(\frac{X_n^4 - N}{4X_n^3}\right)$ 1

$= \frac{4X_n^4 - X_n^4 + N}{4X_n^3}$ 1

$= \frac{3X_n^4 + N}{4X_n^3}$ 1

$= \frac{3}{4}X_n + \frac{N}{4X_n^3}$ 1

for $X = \sqrt[4]{45.7}$, $f(x) = X^4 - 45.7$ 1

$f(2) = 16 - 45.7 < 0$ and $f(3) = 81 - 45.7 > 0$ hence $x \in [2,3]$

$$X_0 = \frac{2+3}{2} = 2.5$$ 1

$$X_1 = \frac{3}{4}X_0 + \frac{N}{4X_0^3}$$ 1

$$= \frac{3}{4}(2.5) + \frac{45.7}{4(2.5)^3} = 2.6062\cdots$$ 1

$$X_1 = \frac{3}{4}X_1 + \frac{N}{4X_1^3}$$ 0.5

$$= \frac{3}{4}(2.6062) + \frac{45.7}{4(2.6062)^3} = 2.60006\cdots$$ 0.5

$$X_2 \cong 2.600061$$ 0.5

18. $$\det(A) = \begin{vmatrix} \cos A & -\sin A & 0 \\ \sin A & \cos A & 0 \\ 0 & 0 & 1 \end{vmatrix}$$ 0.5

$$= \cos A \begin{vmatrix} \cos A & 0 \\ 0 & 1 \end{vmatrix} - \sin A \begin{vmatrix} -\sin A & 0 \\ 0 & 1 \end{vmatrix}$$ 0.5

$$= \cos^2 A + \sin^2 A = 1$$ 0.5

Now let compute the 9 cofactors

$$A_{11} = \begin{vmatrix} \cos A & 0 \\ 0 & 1 \end{vmatrix} = \cos A$$ 1

$$A_{22} = \begin{vmatrix} \cos A & 0 \\ 0 & 1 \end{vmatrix} = \cos A$$ 1

$$A_{21} = \begin{vmatrix} -\sin A & 0 \\ \cos A & 1 \end{vmatrix} = -\sin A$$ 1

$$A_{12} = \begin{vmatrix} -\sin A & 0 \\ 0 & 1 \end{vmatrix} = -\sin A$$ 1

$$A_{31} = \begin{vmatrix} -\sin A & 0 \\ \cos A & 0 \end{vmatrix} = 0$$ 1

$$A_{32} = -\begin{vmatrix} \cos A & 0 \\ \sin A & 0 \end{vmatrix} = 0$$ 1

$$A_{13} = \begin{vmatrix} \sin A & \cos A \\ 0 & 0 \end{vmatrix} = 0$$ 1

$$A_{23} = -\begin{vmatrix} \cos A & -\sin A \\ 0 & 0 \end{vmatrix} = 0$$ 1

$$A_{33} = \begin{vmatrix} \cos A & -\sin A \\ \sin A & \cos A \end{vmatrix} = \cos^2 A + \sin^2 A = 1$$ bb..1

$$Adj = \begin{pmatrix} \cos A & \sin A & 0 \\ -\sin A & \cos A & 0 \\ 0 & 0 & 1 \end{pmatrix}$$ 1

$$A \cdot Adj = \begin{pmatrix} \cos A & -\sin A & 0 \\ \sin A & \cos A & 0 \\ 0 & 0 & 1 \end{pmatrix} \begin{pmatrix} \cos A & \sin A & 0 \\ -\sin A & \cos A & 0 \\ 0 & 0 & 1 \end{pmatrix}$$ 0.5

$$= \begin{pmatrix} \cos^2 A + \sin^2 A & 0 & 0 \\ 0 & \cos^2 A + \sin^2 A & 0 \\ 0 & 0 & \cos^2 A + \sin^2 A \end{pmatrix}$$ 0.5

$$= \begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix}$$ 0.5

also $\det(A)I = 1 \begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix}$ 1

hence $A \cdot Adj = \det(A)I$

....1

19. i)

x_i	y_i	$x_i y_i$	x_i^2	y_i^2
-5	33	-165	25	1089
-1	25	-25	1	625
3	17	51	9	289
10	3	30	100	9
13	-3	-39	169	9
$\sum x_i =$ 20	$\sum y_i =$ 75	$\sum x_i y_i =$ -148	$\sum x_i^2 =$ 3o4	$\sum y_i^2 =$ 2021

.........................0.5 marks for each row = 3 marks (considering last six rows)

$\bar{x} = \frac{\sum x_i}{n} = \frac{20}{5} = 4 \text{ , } \bar{y} = \frac{\sum y_i}{n} = \frac{75}{5} = 15$ 1

$$r = \frac{n\sum x_i y_i - \sum x_i \sum y_i}{\sqrt{n\sum x_i - \left(\sum x_i\right)^2}\sqrt{n\sum y_i^2 - \left(\sum y_2{}^2\right)}}$$ 1

$$= \frac{5(-148) - 20(75)}{\sqrt{5(3o4) - (20)^2}\sqrt{5(2041) - (75)^2}}$$ 1

$$\bar{x} = = \frac{-740 - 1500}{\sqrt{1120}\sqrt{4480}}$$ 1

$$= \frac{-2240}{2240}$$ 0.5

$= -1$ 0.5

Hence r $= -1$,there is a negative perfect correlation. The points are on straight line.

ii) $a=\dfrac{n\sum x_i y-\sum x_i\sum y_i}{n\sum x_i^2-\left(\sum x_i\right)^2}$ 1

$=\dfrac{5(-148)-20(75)}{5(304)-(20)^2}$ 1

$=\dfrac{-740-1500}{1120}$ 0.5

$=\dfrac{-2240}{1120}=-2$ 0.5

$b=\bar{y}-a\bar{x}$ 1

$=15+2(4)=23$ 0.5

The regression $y=-2x+23$ 0.5

iii) When $y=16$

$16=-2x+23\Rightarrow 2x=23-16$ 1

$x=\dfrac{7}{2}=3.5$ 1

20. a) Given that $p(B/A)=\dfrac{5}{8}$, $p(A)=\dfrac{3}{7}$ 1

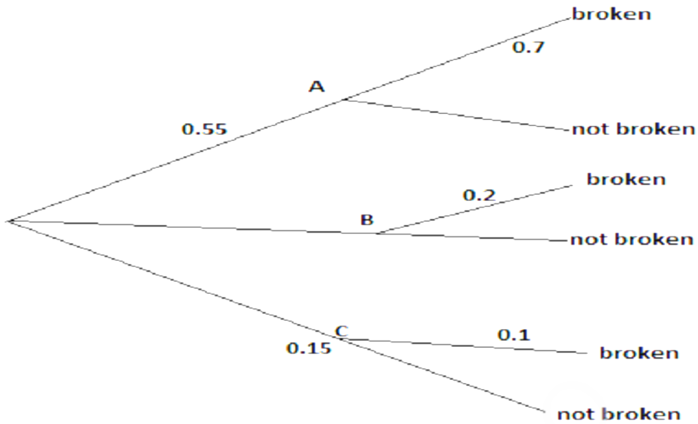
$p(B/A)=\dfrac{p(A\cap B)}{p(A)}$ 2

$\Rightarrow p(A\cap B)=p(B/A)p(A)$ 1

$=\dfrac{5}{8}\cdot\dfrac{3}{7}$

$=\dfrac{15}{56}$ 1

b)



....1 mark for each line = 6 marks

$p(broken) = p(A \cap broken) + p(B \cap broken) + p(C \cap broken)$ 1

$= 0.55 \times 0.7 + 0.30 \times 0.2 + 0.15 \times 0.1$ 0.5

$= 0.385 + 0.06 + 0.015 = 0.46$ 0.5

$p(A / broken) = \frac{p(A \cap broken)}{p(broken)}$ 1

$= \frac{0.385}{0.46}$ 0.5

$p(A / broken) = 0.836$ 0.5