

Secondary 4 Mathematics: Matrices

1. Definition of a Matrix

- A matrix is a rectangular array of numbers arranged in rows and columns
- Example $\begin{pmatrix} 1 & 3 \\ 5 & 7 \\ 9 & 11 \end{pmatrix}$ is a matrix with 3 rows and 2 columns.
 - We can say the matrix above has an order of 3 by 2 and is known as a 3×2 matrix.
- In general, a $m \times n$ matrix has m rows and n columns. The numbers inside a matrix are called the elements of the matrix.

2. Addition and Subtraction of Matrices

$$\begin{pmatrix} a & b \\ c & d \end{pmatrix} \pm \begin{pmatrix} e & f \\ g & h \end{pmatrix} = \begin{pmatrix} a \pm e & b \pm f \\ c \pm g & d \pm h \end{pmatrix}$$

Example

$$\begin{pmatrix} 1 & 3 \\ 5 & 7 \\ 9 & 11 \end{pmatrix} + \begin{pmatrix} 11 & 3 \\ 5 & 6 \\ 4 & 12 \end{pmatrix} = \begin{pmatrix} 1+11 & 3+3 \\ 5+5 & 7+6 \\ 9+4 & 11+12 \end{pmatrix} \\ = \begin{pmatrix} 12 & 6 \\ 10 & 13 \\ 13 & 23 \end{pmatrix}$$

3. Equal Matrices

- Two matrices are equal if they have the same order and have the same corresponding elements.

$$\text{If } A = \begin{pmatrix} a & b \\ c & d \end{pmatrix}, B = \begin{pmatrix} e & f \\ g & h \end{pmatrix} \text{ and } A = B, \text{ then } \begin{pmatrix} a & b \\ c & d \end{pmatrix} = \begin{pmatrix} e & f \\ g & h \end{pmatrix}$$

$$\therefore a = e, b = f, c = g, d = h$$

4. Multiplication of a Matrix by a Real Number

- When a matrix is multiplied by a real number k , the product will be the matrix with each of its elements multiplied by k .

$$k \begin{pmatrix} a & b \\ c & d \end{pmatrix} = \begin{pmatrix} ka & kb \\ kc & kd \end{pmatrix}$$

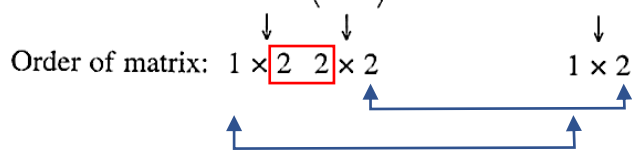
Example

$$3 \begin{pmatrix} 2 & 4 & 6 \\ 1 & 5 & 9 \end{pmatrix} = \begin{pmatrix} 2 \times 3 & 4 \times 3 & 6 \times 3 \\ 1 \times 3 & 5 \times 3 & 9 \times 3 \end{pmatrix} \\ = \begin{pmatrix} 6 & 12 & 18 \\ 3 & 15 & 27 \end{pmatrix}$$

5. Multiplication of Two Matrices

- For matrix multiplication of two matrices **A** and **B**, the product **AB** is only possible when the number of columns of **A** = number of rows of **B**

Example: $\begin{pmatrix} 2 & 3 \end{pmatrix} \begin{pmatrix} 1 & 2 \\ 3 & 4 \end{pmatrix} = \begin{pmatrix} 2 \times 1 + 3 \times 3 & 2 \times 2 + 3 \times 4 \end{pmatrix} = \begin{pmatrix} 11 & 16 \end{pmatrix}$



- The multiplication of its matrices is not commutative, i.e. **AB** $\neq$ **BA**
- The multiplication of matrices is associative, i.e. **A(BC)** = **AB(C)**

Matrices (Worksheet 1)

1. Given that $\mathbf{P} = \begin{pmatrix} 1 & 2 \\ 3 & 4 \end{pmatrix}$, $\mathbf{Q} = \begin{pmatrix} 2 & 2 \\ 6 & 4 \end{pmatrix}$ and $\mathbf{R} = \begin{pmatrix} 2 & 4 \\ 6 & 8 \end{pmatrix}$, find

(a) $\mathbf{P} + \mathbf{R}$

Answer: (a) _____

(b) $\mathbf{R} - \mathbf{Q}$

Answer: (b) _____

(c) $2\mathbf{R} - \mathbf{P}$

Answer: (c) _____

2. Given that $\mathbf{P} = \begin{pmatrix} 10 & 5 \\ 3 & -2 \end{pmatrix}$, $\mathbf{Q} = \begin{pmatrix} x & 1 \\ 0 & -1 \end{pmatrix}$ and $\mathbf{R} = \begin{pmatrix} 15 & y \\ 3 & -1 \end{pmatrix}$, find the values of x and y such that $\mathbf{P} - \mathbf{Q} = \mathbf{R}$.

Answer: $x =$ _____

$y =$ _____

3. Given that $\mathbf{P} = \begin{pmatrix} 1 & x \\ 5 & 0 \end{pmatrix}$, $\mathbf{Q} = \begin{pmatrix} 0 & 5 \\ y & 1 \end{pmatrix}$ and $\mathbf{R} = \begin{pmatrix} 2 & 2 \\ 6 & 4 \end{pmatrix}$, find the values of x and y and the scalar k such that $\mathbf{P} + 2\mathbf{Q} = k\mathbf{R}$.

Answer: $x =$ _____

$y =$ _____

$k =$ _____

4. Given that $\mathbf{A} = \begin{pmatrix} -3 & -1 \\ 1 & 0 \end{pmatrix}$, $\mathbf{B} = \begin{pmatrix} -1 \\ 2 \end{pmatrix}$ and $\mathbf{C} = (5 \quad -1)$, find

(a) $\mathbf{AB}$,

(b) $\mathbf{BC}$,

(c) $\mathbf{A}^2$

Answer: (a) _____

(b) _____

(c) _____

5. It is given that $\begin{pmatrix} 3 & -2 & 0 \\ 1 & 0 & 2 \end{pmatrix} \begin{pmatrix} a \\ 9 \\ b \end{pmatrix} = \begin{pmatrix} 6 \\ -7 \end{pmatrix}$. Find the value of a and of b .

Answer: $a =$ _____

$b =$ _____

6. If h and k are constants such that $h \begin{pmatrix} 2 \\ 8 \end{pmatrix} + k \begin{pmatrix} 3 \\ 4 \end{pmatrix} = \begin{pmatrix} 16 \\ 48 \end{pmatrix}$, find the values of h and k .

Answer: $h =$ _____

$k =$ _____

7. It is given that $\mathbf{A} = \begin{pmatrix} 1 & 0 & 1 \end{pmatrix}$, $\mathbf{B} = \begin{pmatrix} 1 \\ -28 \\ 2 \end{pmatrix}$, $\mathbf{C} = \begin{pmatrix} 1 & -3 \\ 5 & 0 \end{pmatrix}$ and $\mathbf{AB} = 2\mathbf{D}$. Find

(a) $\mathbf{D}$

(b) $\mathbf{C}^2$

Answer: (a) $\mathbf{D} =$ _____

(b) $\mathbf{C}^2 =$ _____

8. Given that $\begin{pmatrix} 2 & z \\ 5 & x \end{pmatrix} = \begin{pmatrix} y & 4 \\ 5 & -2 \end{pmatrix} \begin{pmatrix} 1 & 3 \\ 0 & 2 \end{pmatrix}$, find the values of x , y and z .

Answer: $x =$ _____

$y =$ _____

$z =$ _____

9. A drink stall sells ice-lemon tea and barley drink, each available in small, regular and large cups. The number of cups of drinks sold over a 10-minute period is given in the table below.

Size of cup	Small	Regular	Large
Ice-lemon tea	4	8	2
Barley	1	5	0
Price per cup	\$1.30	\$1.50	\$1.80

It is given that $\mathbf{M} = \begin{pmatrix} 4 & 8 & 2 \\ 1 & 5 & 0 \end{pmatrix}$ and $\mathbf{N} = \begin{pmatrix} 1.3 \\ 1.5 \\ 1.8 \end{pmatrix}$.

- (a) (i) Find $\mathbf{MN}$.
(ii) Explain what your answer (a)(i) represents.

Answer: (a)(i) $\mathbf{MN} =$ _____

(a)(ii) _____

- (b) (i) Given that $\mathbf{P} = \begin{pmatrix} 1 & 1 \end{pmatrix}$, find $\mathbf{PM}$.
(ii) Explain what your answer (b)(i) represents.

Answer: (b)(i) $\mathbf{PM} =$ _____

(b)(ii) _____

10. A toy factory makes toy cars and toy trains. The following table is used in calculating the cost of making each toy.

	Labour (hours)	Metal Cast (pieces)	Paint (tins)
Car	2	3	2
Trains	3	P	1

Labour costs \$8 per hour, metal cast costs \$1 per piece and paint costs \$ q per tin. The information can be summarized in the matrices **A** and **B**, where

$$\mathbf{A} = \begin{pmatrix} 2 & 3 & 2 \\ 3 & p & 1 \end{pmatrix} \text{ and } \mathbf{B} = \begin{pmatrix} 8 \\ 1 \\ q \end{pmatrix}.$$

- (a) Given that $\mathbf{AB} = \begin{pmatrix} 29 \\ 35 \end{pmatrix}$, find the value of p and of q .

Answer: (a) $p =$ _____

$q =$ _____

- (b) Evaluate $\begin{pmatrix} 200 & 150 \end{pmatrix} \begin{pmatrix} 29 \\ 35 \end{pmatrix}$.

Answer: (b) _____

- (c) Explain what your answer to (b) represents.

Answer : (c) _____

Matrices (Worksheet 2)

1. In store A, paint costs \$23.20 per litre, detergent costs \$4.50 per litre and alcohol costs \$9.80 per litre. In store B, paint costs \$19.70 per litre, detergent costs \$5.50 per litre and alcohol costs \$9.20 per litre.

This information can be represented by the matrix $\mathbf{Q} = \begin{pmatrix} \overset{A}{23.2} & \overset{B}{19.7} \\ 4.5 & 5.5 \\ 9.8 & 9.2 \end{pmatrix} \begin{matrix} \text{Paint} \\ \text{Detergent} \\ \text{Alcohol} \end{matrix}$

- (a) John buys 8 litres of paint, 6 litres of detergent and 5 litres of alcohol.

Paul buys 7 litres of paint, 5 litres of detergent and 10 litres of alcohol.

Represent their purchase in a 2×3 matrix $\mathbf{P}$.

Answer: (a) $\mathbf{P} =$ _____

- (b) Evaluate the matrix $\mathbf{R} = \mathbf{PQ}$.

Answer: (b) $\mathbf{R} =$ _____

(c) How much money would Paul save by shopping in store B?

Answer: (c) Savings = \$ _____

(d) John shops in store A.

He has a shopping voucher that gives a discount of 20%.

How much does he pay in total for his items?

Answer: (d) \$ _____

2. Find the matrix $\mathbf{A}$ such that $4\mathbf{A} + \begin{pmatrix} 2 & -3 \\ -2 & 4 \end{pmatrix} = \begin{pmatrix} 4 & 3 \\ 6 & 8 \end{pmatrix}$.

Answer: $\mathbf{A} =$ _____

3. Given that $\mathbf{D} = \begin{pmatrix} 3 & -4 \\ 0 & 2 \end{pmatrix}$, $\mathbf{E} = \begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix}$ and $\mathbf{F} = \begin{pmatrix} -2 & -1 \\ 1 & 4 \end{pmatrix}$,
evaluate $2\mathbf{D} + \mathbf{E} - 3\mathbf{F}$.

Answer: _____

4. Two cafes sell coffee from different countries. The sale and price of the coffee at the two cafés are shown in the table below.

	Ethopia (\$8)	Myanmar (\$6)	Columbia (\$7)
Café A	18	9	10
Café B	15	7	24

- (a) Represent the information above by a 2×3 matrix $\mathbf{C}$.

Answer: (a) $\mathbf{C} =$ _____

- (b) Evaluate the matrix $\mathbf{S} = \mathbf{C} \begin{pmatrix} 1 \\ 1 \\ 1 \end{pmatrix}$.

Answer: (b) $\mathbf{S} =$ _____

(c) Explain what the elements of **S** represent.

(d) Represent the price of the coffee using matrix **P**.

Answer: (d) **P** = _____

(e) Using matrix **C** and **P**, find the total sales **T** by each café. .

Answer: (e) **T** = _____

5. A prata shop operates for 7 days a week.

The matrix **M** represents the number of pratas of different types that are sold each day.

$$\mathbf{M} = \begin{matrix} & \begin{matrix} \text{Plain} & \text{Egg} & \text{Milo} & \text{Chocolate} \end{matrix} \\ \begin{pmatrix} 57 & 38 & 23 & 18 \\ 42 & 29 & 13 & 16 \end{pmatrix} & \begin{matrix} \text{Regular} \\ \text{Upsize} \end{matrix} \end{matrix}$$

(a) Evaluate **P = 7M**.

Answer: (a) **P** = _____

(b) Plain prata costs \$0.50 each to make.

Egg prata costs \$0.75 each to make.

Milo prata costs \$1.20 each to make.

Chocolate prata costs \$1.20 each to make.

Represent these amounts in a 4×1 column matrix $\mathbf{N}$.

Answer: (b) $\mathbf{N} =$ _____

(c) Evaluate the matrix $\mathbf{T} = \mathbf{PN}$.

Answer: (c) $\mathbf{T} =$ _____

(d) State what each of the elements of $\mathbf{T}$ represents.

6. A Thai restaurant sells 3 different types of dinner sets. Each dinner set contains packets of 4 different types of food items: fried rice, stir fried vegetables, sambal tofu and mango sticky rice.

Matrix **T** shows the breakdown of the number of packets of each type of food item within the 3 different sets.

$$\mathbf{T} = \begin{array}{ccccc} \text{Set} & \text{A} & \text{B} & \text{C} & \\ \left(\begin{array}{ccc} 2 & 4 & 7 \\ 1 & 2 & 3 \\ 1 & 1 & 2 \\ 2 & 3 & 4 \end{array} \right) & \text{Fried Rice} & & & \\ & \text{Stir Fried Vegetables} & & & \\ & \text{Sambal Tofu} & & & \\ & \text{Mango Sticky Rice} & & & \end{array}$$

- (a) On average, the restaurant sells 5 set A, 3 set B and 6 set C per day.

Represent this as a 3×1 matrix **R**.

Answer: (a) **R** = _____

- (b) Evaluate the matrix **N** = **7R**.

Answer: (b) **N** = _____

- (c) Evaluate **M** = **TN**.

Answer: (c) **M** = _____

(d) State what each of the element(s) of **M** represent.

(e) (i) If the restaurant sells Set A at \$24, set B at \$43 and set C at \$70, calculate the total sales from the dinner sets.

Answer: (e)(i) Total sales = \$ _____

(ii) Instead of buying dinner sets where the combination of food items is fixed, the food items can also be bought individually (this is known as á la carte).

For á la carte purchase, a packet of rice costs \$4, mixed vegetable \$6.50, sambal tofu \$5 and mango sticky rice \$5. In order to boost business, the restaurany also extends a discount of 10% for all á la carte purchases.

Calculate the percentage loss in sales when the restaurant sells dinner sets instead of á la carte.

Answer: (e)(ii) % loss = _____

7. Three brands of tennis shoes, Ace, Niks, Wils, are sold at two stores, Joe Sporting House and Mikasa Sports.

The following table shows the price of each brand at the two stores.

	Price of one pair of shoes (\$)	
	Joe Sporting House	Mikasa Sports
Ace	159	175
Niks	230	215
Wils	205	223

- (a) Represent the information in the above table by a 3×2 matrix **A**.

Answer: (a) **A** = _____

A tennis club manager plans to order 8, 25 and 12 pairs of brands Ace, Niks and Wils respectively. She can enjoy free delivery of the shoes if she orders from the same store.

- (b) Write down a 3×1 matrix **P** to represent the orders.

Answer: (b) **P** = _____

- (c) Evaluate the matrix **C**, where **C** = **PA**.

Answer: (c) **C** = _____

(d) Explain what the elements in **C** represent.

(e) Both stores Joe Sporting House and Mikasa Sports are offering a discount of 10% and 15% respectively.

- (i) Write down a 2×2 matrix **Q** such that the matrix multiplication **AQ** give the discounted price of each brand of shoes from each store.

Answer: (e)(i) **Q** = _____

- (ii) Hence, using matrix multiplication, determine which store the manager should buy the tennis shoes from.

Answer: (e)(ii) She should buy from _____

Name : _____

Date: _____

Matrices (Worksheet 3)

1. A satay shop offers two types of combo sets.

Combo Set X includes 20 sticks of chicken (C), 10 sticks of mutton (M) and 10 sticks of beef (B).

Combo Set Y includes 25 sticks of chicken (C), 15 sticks of mutton (M) and no beef (B).

- (a) Represent the information in the above table by a 2×3 matrix **P**.

Answer: (a) **P** = _____

- (b) The cost of a stick of satay is 90 cents for chicken, \$1.20 for mutton and \$ x for beef.

Write down a 3×1 matrix **T** to represent this information.

Answer: (b) **T** = _____

- (c) Find, in terms of x , matrix **Q**, where **Q** = **PT**.

Answer: (c) **Q** = _____

(d) Explain what the elements in **Q** represent.

(f) The total cost is the same for both Set X and Y. Calculate x .

Answer: (f) $x =$ _____

2. A factory supplies coffee beans to shop A , B and C .

The matrix, **P**, shows the number of bags of 5 kg, 10 kg and 15 kg sold to shop A , B and C .

$$\mathbf{P} = \begin{matrix} & \begin{matrix} 5\text{kg} & 10\text{kg} & 15\text{kg} \end{matrix} \\ \begin{pmatrix} 20 & 50 & 30 \\ 40 & 60 & 20 \\ 30 & 20 & 50 \end{pmatrix} & \begin{matrix} \text{Shop } A \\ \text{Shop } B \\ \text{Shop } C \end{matrix} \end{matrix}$$

The factory delivers the coffee beans to shop A , B and C three times yearly.

(a) Evaluate the matrix $\mathbf{S} = 3\mathbf{P}$.

Answer: (a) $\mathbf{S} =$ _____

(b) The cost of 5 kg, 10 kg and 15 kg bags are \$9.50, \$12.60 and \$23 respectively.

Represent the prices of the coffee beans in a 2×3 matrix **Q**.

Answer: (b) $\mathbf{Q} =$ _____

(c) Evaluate the matrix $\mathbf{T} = \mathbf{S}\mathbf{Q}$.

Answer: (c) $\mathbf{T} =$ _____

(d) State what each of the elements in $\mathbf{T}$ represents.

3. The following table shows the number of property transactions of an agent from January to March 2019.

Type of property	Sale Transaction	Rental Transaction
HDB Flats	6	8
Private Condominium	4	2
Landed Houses	3	1

The information above is represented by the matrix $\mathbf{P} = \begin{pmatrix} 6 & 8 \\ 4 & 2 \\ 3 & 1 \end{pmatrix}$ and $\mathbf{Q} = \begin{pmatrix} 1 \\ 1 \end{pmatrix}$.

(a) Evaluate $\mathbf{W} = \mathbf{P}\mathbf{Q}$ and explain the significance of the elements in $\mathbf{W}$.

Answer: (a) $\mathbf{W} =$ _____

Significance of the elements in $\mathbf{W}$: _____

The commission received and the government tax charged under each type of transaction is shown in the table below:

	HDB Flats	Private Condominium	Landed Houses
Commission	\$3000	\$7000	\$11000
Government Tax	\$800	\$1800	\$2500

(b) Represent the above information with **R** and evaluate **S = RW**.

Explain the significance of the elements in **S**.

Answer: (b) **S** = _____

Significance of the elements in **R** : _____

- (c) Write down another matrix $\mathbf{T}$ such that the product $\mathbf{TS}$ gives the amount of money earned by the agent after dedecuting the government tax from January to March 2019. Hence, find the amount of money earned by the agent.

Answer: (c) $\mathbf{T} =$ _____

Amount of money earned = \$ _____

4. A business owner operates two beauty salons at two different locations.

The table below shows the number of staff in these 2 salons.

	Facial theapist	Hair stylist	Nail technicain
Glow@Clementi	7	3	5
Glow@Tampines	6	4	2

The staff monthly salary is made up of a basic wage component and fringe benefits.

The table below shows the basic wage and fringe benefits of the staff.

	Basic Wage (\$)	Fringe benefits (\$)
Facial theapist	2500	200
Hair stylist	3500	300
Nail technicain	2000	80

It is given that the matrix $\mathbf{P} = \begin{pmatrix} 7 & 3 & 5 \\ 6 & 4 & 2 \end{pmatrix}$ and the matrix $\mathbf{Q} = \begin{pmatrix} 2500 & 200 \\ 3500 & 300 \\ 2000 & 80 \end{pmatrix}$.

- (a) Evaluate the matrix $\mathbf{R} = \mathbf{PQ}$,

Answer: (b) $\mathbf{R} =$ _____

- (b) State what each of the elements of $\mathbf{R}$ represents.

- (c) The fringe benefits for each staff increased by 10. Using the matrix **R** found in part (a) and another matrix, find the new total monthly salary paid to all the staff at each salon respectively.

Answer: (c) Glow@Clementi = \$ _____

Glow@Tampines = \$ _____

5. A fitness centre offers daily zumba classes for morning and afternoon classes.
On every weekday morning, 15 males and 10 females will attend the zumba class, while 20 males and 15 females attend the afternoon zumba class.
This information may be represented by the matrix **D** below.

$$\mathbf{D} = \begin{matrix} & \begin{matrix} \text{males} & \text{females} \end{matrix} \\ \begin{pmatrix} 15 & 10 \\ 20 & 15 \end{pmatrix} & \begin{matrix} \text{morning} \\ \text{afternoon} \end{matrix} \end{matrix}$$

On each weekend, 30 males and 20 females will attend the morning class, while 25 males and 25 females will attend the afternoon class.

- (a) Represent the number of people attending the fitness class on each weekend by a 2×3 matrix **E**.

Answer: (a) **E** = _____

(b) Evaluate the matrix $\mathbf{S} = 5\mathbf{D} + 2\mathbf{E}$.

Answer: (b) $\mathbf{S} =$ _____

(c) The fitness center charges each person \$10 for a morning session and \$15 for an afternoon session. Represent the charges by a row matrix $\mathbf{P}$.

Answer: (c) $\mathbf{S} =$ _____

(d) Evaluate the matrix $\mathbf{T} = \mathbf{PS}$.

Answer: (d) $\mathbf{T} =$ _____

(e) State what the elements of $\mathbf{T}$ represent.

6. The number of copies of Chinese and English copies of a title were sold in two outlets of a bookstore in a particular month as shown in the following table.

	Chinese	English
Hougang outlet	35	46
Bishan outlet	43	70

The average production costs of a Chinese copy and an English copy of the title are \$15 and \$10 respectively.

- (a) The information above can be represented by the matrices $\mathbf{N} = \begin{pmatrix} 35 & 46 \\ 43 & 70 \end{pmatrix}$ and $\mathbf{C} = \begin{pmatrix} 15 \\ 10 \end{pmatrix}$

- (i) Find the matrix $\mathbf{NC}$.

Answer: (a) $\mathbf{NC} =$ _____

- (ii) State what does the elements of $\mathbf{NC}$ represent.

- (b) Given that the selling prices of Chinese and English copies are \$ p and \$ q respectively at the two outlets, write down a 2×1 matrix, $\mathbf{S}$, to represent this information. Hence, find the matrix $\mathbf{NS}$ in terms of p and q .

Answer: (c) $\mathbf{S} =$ _____ $\mathbf{NS} =$ _____

- (c) The total earnings in the Hougang and Bishan outlets from selling all the copies of the title are \$1905 and \$2745 respectively. Using your answers from (a)(i) and (b), solve for the values of p and q .

Answer: (c) $p =$ _____ , $q =$ _____

7. The following table shows the number of letters, cards and parcels sent by Kim and Mary.

	Letters	Cards	Parcels
Kim	4	10	2
Mary	5	5	3

- (a) The information for the number of letters, cards and parcels sent by Kim and Mary can be presented by a 2×3 matrix, **N**. Write down the matrix **N**.

Answer: (a) **N** = _____

- (b) Postage is charged at \$0.30 for a letter, \$0.50 for a card and \$6 for a parcel. Write down a 3×1 matrix **C** to represent each type of postage charge.

Answer: (b) **C** = _____

- (c) (i) Given **P** = **NC**, evaluate **P**.

Answer: (c)(i) **P** = _____

- (ii) State what does the elements of **P** represent.

- (d) If the postage is increased by 20% for a letter, 10% for a postcard and 5% for a parcel,
- (i) formulate and write down a 3×3 matrix, $\mathbf{R}$, such that the matrix $\mathbf{RC}$ will give the revised cost for each type of postage charge.

Answer: (c)(i) $\mathbf{R} =$ _____

- (ii) calculate the total amount that Kim and Mary need to pay to send out the letters, cards, parcels with the revised postage charges.

Answer: (c)(ii) \$ _____

8. The table below shows the amount of flour, sugar and number of eggs needed for each type of pastry sold in a café.

	Flour (g)	Sugar (g)	Number of eggs
Cookie	90	50	1.5
Cake	220	200	8
Pancake	60	80	2

The above information is represented by a matrix $\mathbf{D} = \begin{pmatrix} 90 & 50 & 1.5 \\ 220 & 200 & 8 \\ 60 & 80 & 2 \end{pmatrix}$.

- (a) Each kg of flour and sugar costs \$1.50 and \$1.80 respectively. A dozen of eggs costs \$2.70. Complete the cost in \$ for every gram of flour and sugar as well as the cost in \$ for each egg in the table below:

Flour (\$/g)	Sugar (\$/g)	Number of eggs (\$/egg)

- (b) Write down a 3×1 matrix $\mathbf{E}$ such that its elements represent the unit cost of each ingredient needed for the various pastries.

Answer: (b) $\mathbf{E} =$ _____

- (c) Calculate $\mathbf{DE}$.

Answer: (c) $\mathbf{DE} =$ _____

(d) State what the elements of **DE** represent.

(e) The café prepared 70 cookies, 30 cakes and 120 pancakes on a particular day. Using matrix multiplication, calculate the total cost of the basic ingredients for all the pastries prepared on this day.

Answer: (e) \$ _____