CHAPTER 3: SURDS

CHAPTER ANALYSIS $\sqrt{x}$

- Four operations on surds, including rationalizing the denominator.
- Simplifying surds.
- Solving equations involving surds.

Surds is a topic that will be tested together with several topics such as Differentiation, Integration.

The questions tested on this topic will always involve RATIONALISATION.

This chapter has a pre-requisite of E-Math Chapter 3: Indices.

LAWS OF INDICES

- You are expected to know Indices before starting on the topic of Surds.

- Some laws of indices are related to the 4 operations of surds ("Same Power")

Common Mistake

The following 2 statements are **INCORRECT**, but many students still get confused and use these 2 statements in their solutions

$$a^m + b^m = (a+b)^m \text{ ......}(*)$$
$$a^m - b^m = (a-b)^m$$

Proof that (*) is incorrect

By substituting values of $a = 1$, $b = 2$ and $m = 3$

$$\text{LHS} = 1^3 + 2^3 = 9$$

$$\text{RHS} = (1+2)^3 = 27$$

$$\therefore \textbf{LHS} \neq \textbf{RHS}$$

Laws of Indices	
Same Base	$a^m \times a^n = a^{m+n}$
	$\frac{a^m}{a^n} = a^{m-n}$
	$(a^m)^n = a^{mn}$
Same Power	$a^m \times b^m = (ab)^m$
	$\frac{a^m}{b^m} = \left(\frac{a}{b}\right)^m$
Radicals	$\sqrt[n]{a} = a^{\frac{1}{n}}$
	$a^{\frac{m}{n}} = \left(\sqrt[n]{a}\right)^m = \sqrt[n]{a^m}$
Others	$a^0 = 1$
	$a^{-n} = \frac{1}{a^n}$

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4 OPERATIONS OF SURDS

- The law of multiplication and division occurs due to law of indices (same power), which explains why we can combine the base (a and b in this case) together.

- The law of addition and subtraction involves factorising the common surd before performing addition/subtraction.

Common misconception about addition/subtraction

$$\sqrt{3} + \sqrt{2} = \sqrt{5}$$

We only can combine the numbers inside the surd when it is multiplication or division.

Laws of Surds	
Multiplication	$\sqrt{a}\times\sqrt{b} = a^{\frac{1}{2}}\times b^{\frac{1}{2}} = (ab)^{\frac{1}{2}} = \sqrt{ab}$
Division	$\sqrt{a} \div \sqrt{b} = \frac{a^{\frac{1}{2}}}{b^{\frac{1}{2}}} = \left(\frac{a}{b}\right)^{\frac{1}{2}} = \sqrt{\frac{a}{b}}$
Addition	$m\sqrt{a} + n\sqrt{a} = (m+n)\sqrt{a}$
Subtraction	$m\sqrt{a} - n\sqrt{a} = (m-n)\sqrt{a}$

RATIONALISATION OF SURDS

We rationalise surds so that we can remove the roots from the denominator since there should not be any roots in your denominators when presented as the final answer.

Case 1: When the denominator is $\sqrt{a}$, we rationalise by multiplying the denominator by $\sqrt{a}$ so that the square root will be removed. However, remember to multiply the numerator by the same surd so that the value of equation remains constant.

Case 2: You rationalise the denominator by multiplying by its conjugate surd. The same rule applies here: remember to multiply the numerator by the same surd so that the value of equation remains constant.

The conjugate surd of $m\sqrt{a} \pm n\sqrt{b}$ will be $m\sqrt{a} \mp n\sqrt{b}$.

Reason behind is to make use of the special identity of:

$$(a+b)(a-b) = a^2 - b^2$$

The act of removing the roots from the denominators. There are **2** cases of rationalisation

- **Case 1:** Denominator of single-term surds
  - Rationalise by multiplying the numerator and denominator by $\sqrt{a}$ to get a

$$\begin{aligned} \frac{3}{\sqrt{12}} &= \left(\frac{3}{\sqrt{12}}\right)\left(\frac{\sqrt{12}}{\sqrt{12}}\right) \\ &= \frac{3\sqrt{2^2 \times 3}}{12} \\ &= \frac{3(2)\sqrt{3}}{12} \\ &= \mathbf{\frac{\sqrt{3}}{2}} \end{aligned}$$

- **Case 2:** Denominator of sum/difference of surds
  - Rationalise by multiplying the numerator and denominator by its conjugate surd to get a rational number

$$\begin{aligned} \frac{1}{\sqrt{5}-2} &= \left(\frac{1}{\sqrt{5}-2}\right)\left(\frac{\sqrt{5}+2}{\sqrt{5}+2}\right) \\ &= \frac{1\left(\sqrt{5}+2\right)}{\left(\sqrt{5}\right)^2 - (2)^2} \\ &= \mathbf{\sqrt{5}+2} \end{aligned}$$

SOLVING EQUATIONS INVOLVING SURDS

$$\sqrt{5x+2} - \sqrt{3x-8} = 0$$

1) Make the equation in the form of LHS = RHS.

$$\sqrt{5x+2} = \sqrt{3x-8}$$

2) Remove the square roots by applying square on both sides .

$$5x + 2 = 3x - 8$$

3) Solve the algebraic equation.

$$2x = -6$$

$$x = -3$$

If you obtain a quadratic equation which results in 2 solutions, check for your solutions by subbing it back into the original equation (question). Reject accordingly if the answers do not match.

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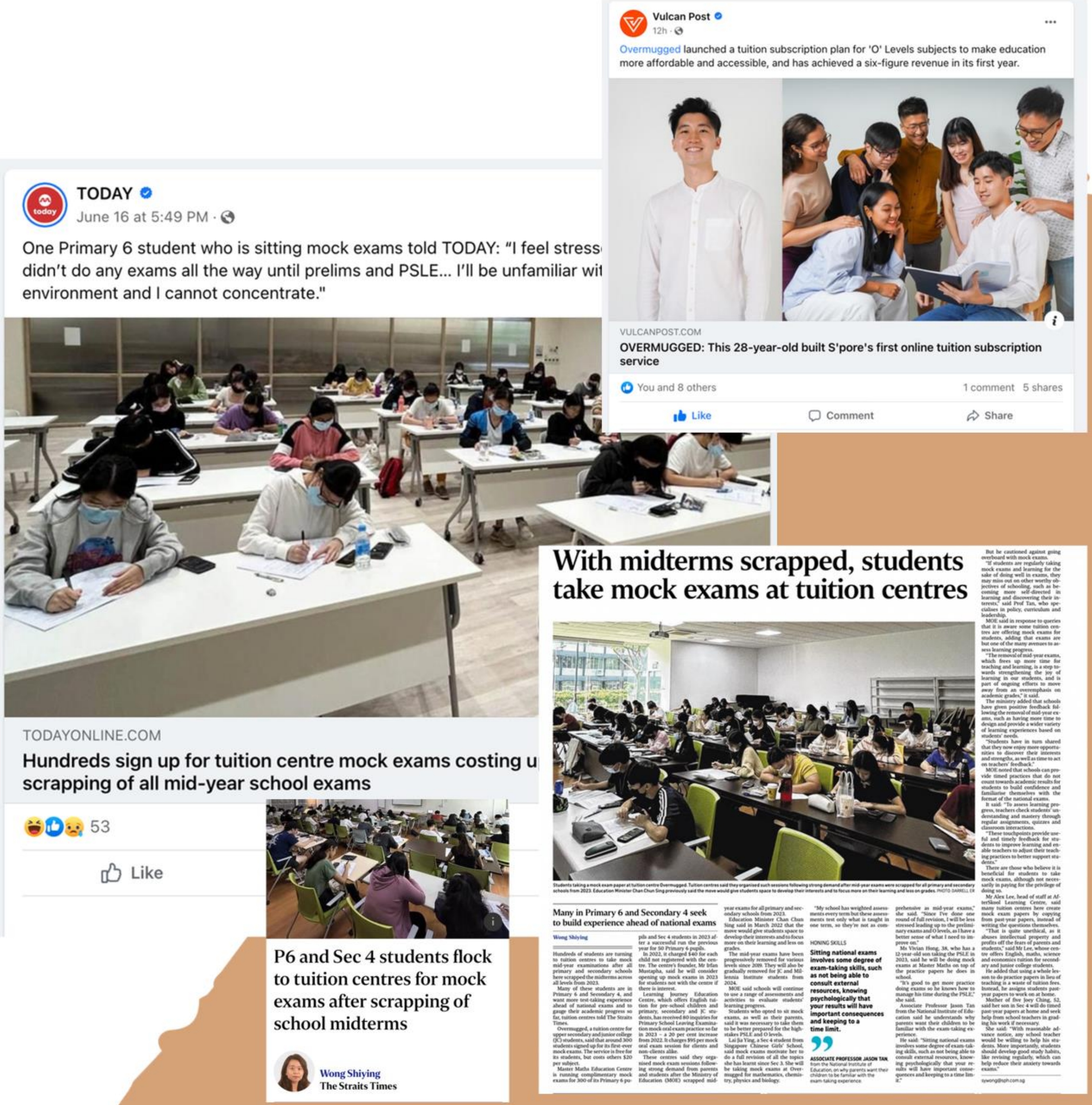

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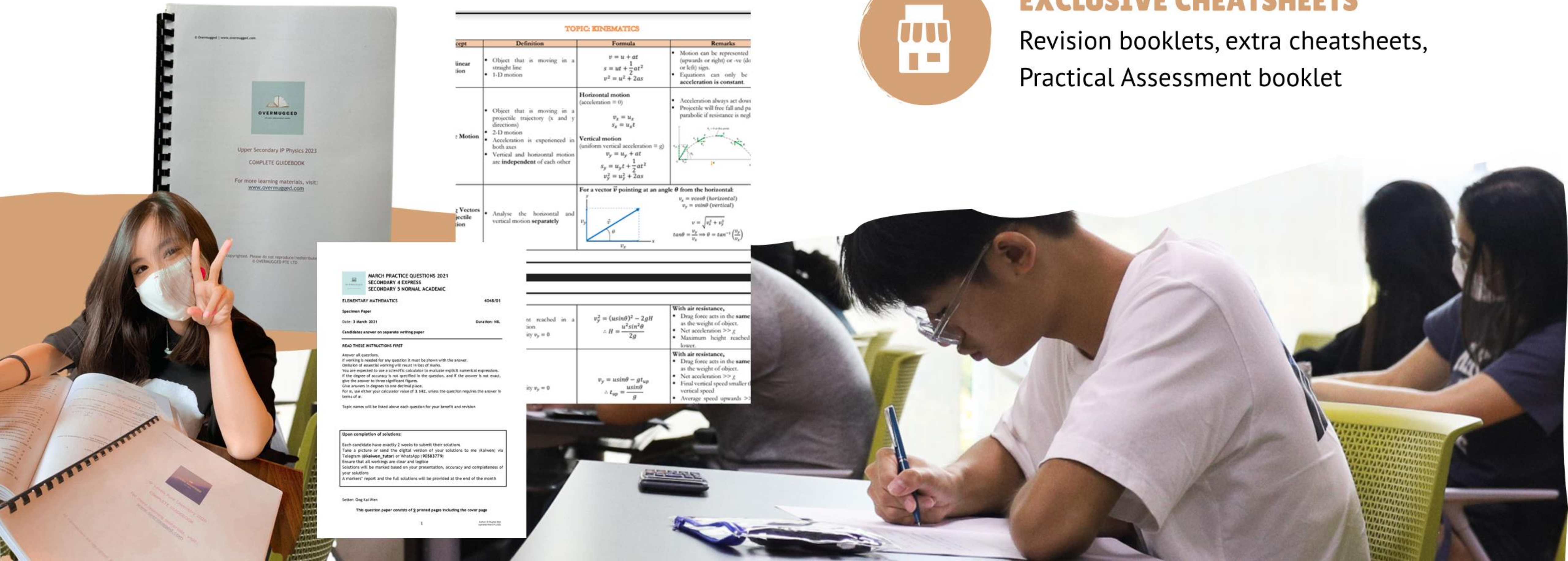

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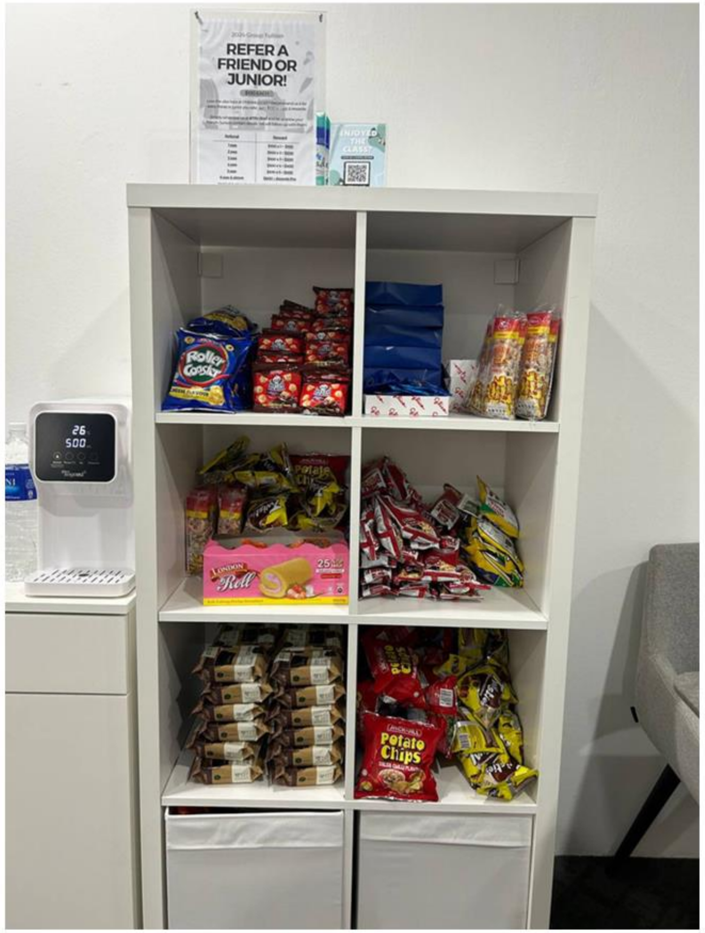

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