2020-DSE MATH EP M2

HONG KONG EXAMINATIONS AND ASSESSMENT AUTHORITY
HONG KONG DIPLOMA OF SECONDARY EDUCATION EXAMINATION 2020

## MATHEMATICS Extended Part Module 2 (Algebra and Calculus) Question-Answer Book

8:30 am - 11:00 am (2½ hours)
This paper must be answered in English

## **INSTRUCTIONS**

- (1) After the announcement of the start of the examination, you should first write your Candidate Number in the space provided on Page 1 and stick barcode labels in the spaces provided on Pages 1, 3, 5, 7, 9, 11 and 13.
- (2) This paper consists of TWO sections, A and B.
- (3) Attempt ALL questions in this paper. Write your answers in the spaces provided in this Question-Answer Book. Do not write in the margins. Answers written in the margins will not be marked.
- (4) Graph paper and supplementary answer sheets will be supplied on request. Write your Candidate Number, mark the question number box and stick a barcode label on each sheet, and fasten them with string INSIDE this book.
- (5) Unless otherwise specified, all working must be clearly shown.
- (6) Unless otherwise specified, numerical answers must be exact.
- (7) No extra time will be given to candidates for sticking on the barcode labels or filling in the question number boxes after the 'Time is up' announcement.

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$$cos(A \pm B) = cos A cos B \mp sin A sin B$$

$$\tan (A \pm B) = \frac{\tan A \pm \tan B}{1 \mp \tan A \tan B}$$

$$2\sin A\cos B = \sin (A+B) + \sin (A-B)$$

$$2\cos A\cos B = \cos(A+B) + \cos(A-B)$$

$$2\sin A\sin B = \cos(A - B) - \cos(A + B)$$

$$\sin A + \sin B = 2\sin\frac{A+B}{2}\cos\frac{A-B}{2}$$

$$\sin A - \sin B = 2\cos\frac{A+B}{2}\sin\frac{A-B}{2}$$

$$\cos A + \cos B = 2\cos\frac{A+B}{2}\cos\frac{A-B}{2}$$

$$\cos A - \cos B = -2\sin\frac{A+B}{2}\sin\frac{A-B}{2}$$

SECTION A (50 marks)

Answers written in the margins will not be marked.

- 1. (a) Expand  $(1-x)^4$ .
  - (b) Find the constant k such that the coefficient of  $x^2$  in the expansion of  $(1+kx)^9(1-x)^4$  is -3.

(4 marks)

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Defin	$e f(x) = \frac{x}{\sqrt{2+x}}$	for all $x > -2$ . Find $f'(2)$ from first principles.	(4 marks
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(a)	Let $x$ be an angle which is not a multiple of $30^{\circ}$ . Prove that
	(i) $\tan 3x = \frac{3 \tan x - \tan^3 x}{1 - 3 \tan^2 x}$ ,
	(ii) $\tan x \tan (60^{\circ} - x) \tan (60^{\circ} + x) = \tan 3x$ .
(b)	Using (a)(ii), prove that $\tan 55^{\circ} \tan 65^{\circ} \tan 75^{\circ} = \tan 85^{\circ}$ . (6 mark
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(a)	Find $\int \sin^2 \theta  d\theta$ .
(b)	Define $f(x) = 4x(1-x^2)^{\frac{1}{4}}$ for all $x \in [0,1]$ . Denote the graph of $y = f(x)$ by $G$ . Let the region bounded by $G$ and the $x$ -axis. Find the volume of the solid of revolution general revolving $R$ about the $x$ -axis.
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5.	(a)	Using mathematical induction, prove that integers $n$ .	$\sum_{k=1}^{n} \frac{1}{k(k+1)(k+2)} = \frac{n(n+3)}{4(n+1)(n+2)}$	for all positive
	(b)	Using (a), evaluate $\sum_{k=4}^{123} \frac{50}{k(k+1)(k+2)}$ .		(7 marks)
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	fine $P = \begin{pmatrix} -5 & -2 \\ 15 & 6 \end{pmatrix}$ and $Q = \begin{pmatrix} 1 & 0 \\ 0 & 0 \end{pmatrix}$ . Let $M = \begin{pmatrix} 1 & a \\ b & c \end{pmatrix}$ such that $ M  = 1$ and $PM = M$ are $a$ , $b$ and $c$ are real numbers.	
(a)	Find $a$ , $b$ and $c$ .	
(b)	Define $R = \begin{pmatrix} 6 & 2 \\ -15 & -5 \end{pmatrix}$ .	
	(i) Evaluate $M^{-1}RM$ .	
	(ii) Using the result of (b)(i), prove that $(\alpha P + \beta R)^{99} = \alpha^{99} P + \beta^{99} R$ for any real numb $\alpha$ and $\beta$ .	
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	SEC	TION	B (50 marks)	
	9.	Let	$f(x) = \frac{(x+4)^3}{(x-4)^2}$ for all real numbers $x \neq 4$ . Denote the graph of $y = f(x)$ by $H$ .	
		(a)	Find the asymptote(s) of $H$ .	(3 marks)
		(b)	Find $f''(x)$ .	(2 marks)
		(c)	Someone claims that there are two turning points of $H$ . Do you agree? Explain your	answer. (2 marks)
		(d)	Find the point(s) of inflexion of $H$ .	(2 marks)
		(e)	Find the area of the region bounded by $H$ , the x-axis and the y-axis.	(3 marks)
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10.	(a)	Using integration by substitution, prove that $\int_{\frac{\pi}{12}}^{\frac{\pi}{6}} \ln \left( \sin \left( \frac{\pi}{4} - x \right) \right) dx = \int_{\frac{\pi}{12}}^{\frac{\pi}{6}} \ln (\sin x) dx$	
		•	(3 marks)
	(b)	Using (a), evaluate $\int_{\frac{\pi}{12}}^{\frac{\pi}{6}} \ln(\cot x - 1) dx$ .	(3 marks)
	(c)	(i) Using $\cot(A - B) = \frac{\cot A \cot B + 1}{\cot B - \cot A}$ , or otherwise, prove that $\cot \frac{\pi}{12} = 2 + \sqrt{3}$	
		(ii) Using integration by parts, prove that $\int_{\frac{\pi}{12}}^{\frac{\pi}{6}} \frac{x \csc^2 x}{\cot x - 1} dx = \frac{\pi}{8} \ln(2 + \sqrt{3}).$	
			(7 marks)
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(E): 
$$\begin{cases} x - y - 2z = 1 \\ x - 2y + hz = k, \text{ where } h, k \in \mathbb{R} \\ 4x + hy - 7z = 7 \end{cases}$$

- (i) Assume that (E) has a unique solution.
  - (1) Prove that  $h \neq -3$ .
  - (2) Solve (E).
- (ii) Assume that h = -3 and (E) is consistent.
  - (1) Prove that k = -2.
  - (2) Solve (E).

(9 marks)

Answers written in the margins will not be marked.

(b) Consider the system of linear equations in real variables x, y, z

(F): 
$$\begin{cases} x - y - 2z = 1 \\ x - 2y + hz = -2, \text{ where } h \in \mathbb{R} \\ 4x + hy - 7z = 7 \end{cases}$$

Someone claims that there are at least two values of h such that (F) has a real solution (x, y, z) satisfying  $3x^2 + 4y^2 - 7z^2 = 1$ . Do you agree? Explain your answer. (4 marks)

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2.		$\overrightarrow{OP} = \mathbf{i} + \mathbf{j} + 4\mathbf{k}$ and $\overrightarrow{OQ} = 5\mathbf{i} - 7\mathbf{j} - 4\mathbf{k}$ , where $O$ is the origin. $R$ is a point ly that $PR: RQ = 1:3$ .	ing on PQ
	(a)	$Find_* \overrightarrow{OP} \times \overrightarrow{OR}$ .	(2 marks)
	(b)	Define $\overrightarrow{OS} = \overrightarrow{OP} + \overrightarrow{OR}$ . Find the area of the quadrilateral $OPSR$ .	(2 marks)
	(c)	Let N be a point such that $\overrightarrow{ON} = \lambda(\overrightarrow{OP} \times \overrightarrow{OR})$ , where $\lambda$ is a real number.	
		(i) Is $\overrightarrow{NR}$ perpendicular to $\overrightarrow{PQ}$ ? Explain your answer.	
		(ii) Let $\mu$ be a real number such that $\overrightarrow{NQ}$ is parallel to $11\mathbf{i} + \mu\mathbf{j} - 10\mathbf{k}$ .	
		(1) Find $\lambda$ and $\mu$ .	
		(2) Denote the angle between $\triangle OPQ$ and $\triangle NPQ$ by $\theta$ . Find $\tan\theta$ .	(8 marks)
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