Name:	
Class:	



#### YEAR 12

## TRIAL 2016

#### MATHEMATICS EXTENSION 1

#### **General Instructions:**

- · Reading Time: 5 minutes.
- · Working Time: 2 hours.
- · Write in black or blue pen.
- Board approved calculators & templates may be used
- · A Reference Sheet is provided.
- In Question 11 14, show all relevant mathematical reasoning and/or calculations.
- Marks may not be awarded for careless or badly arranged working.

## Total Marks 70

Section I: 10 marks

- Attempt Question 1 10.
- Answer on the Multiple Choice answer sheet provided.
- Allow about 15 minutes for this section.

## Section II: 60 Marks

- · Attempt Question 11 14
- Answer on blank paper unless otherwise instructed. Start a new page for each new question.
- Allow about 1 hour & 45 minutes for this section.

The answers to all questions are to be returned in separate *stapled* bundles clearly labelled Question 11, Question 12, etc. Each question must show your Candidate Number.

## Section I

10 marks

Attempt Questions 1 - 10

Allow about 15 minutes for this section

Use the multiple-choice answer sheet for Questions 1-10

1. Let  $\alpha$ ,  $\beta$  and  $\gamma$  be the roots of  $x^3 + px^2 + q = 0$ .

Express  $\frac{1}{\alpha\beta} + \frac{1}{\beta\gamma} + \frac{1}{\gamma\alpha}$  in terms of p and q.

- (A) pq
- (B) -pq
- (C)  $-\frac{p}{q}$
- (D)  $\frac{p}{q}$

2. If 
$$f(x) = \frac{3 + e^{2x}}{4}$$
, what is  $f^{-1}(x) = ?$ 

- (A) ln(4x 3)
- (B)  $\frac{1}{2}\ln(4x-3)$
- (C)  $\ln 4x \ln 3$
- (D)  $\frac{1}{2} (\ln 4x \ln 3)$

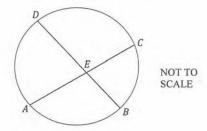
3. A family of 6 adults and 3 children are randomly sitting around a circular table.

What is the number of possible seating arrangements if none of the children sit together?

- (A) 720
- (B) 2 400
- (C) 14 400
- (D) 86 400

JRAHS 2016 TRIAL MATHEMATICS EXTENSION 1 Page 2

4. In the diagram below, chords AC and BD of the circle intersect at E. AC = 9 units, CE = a units, DE = x units and EB = y units



Which of the following statements is true?

- (A) xy = 9a
- (B)  $\frac{x}{y} = \frac{9-a}{a}$
- (C) x(x+y) = a(9-a)
- (D) xy = a(9 a)
- 5. For 0 < x < 1, what is  $\frac{d}{dx} \left( \cos^{-1} \frac{1}{x} \right) = ?$ 
  - $(A) \quad \frac{-1}{x\sqrt{x^2-1}}$
  - (B)  $\frac{1}{x\sqrt{x^2-1}}$
  - (C)  $\frac{-1}{\sqrt{x^2-1}}$
  - (D)  $\frac{-x}{\sqrt{x^2-1}}$
- 6. What is the general solution of  $\cos 2\theta = \frac{\sqrt{2}}{2}$ ?
  - (A)  $\theta = \frac{\pi}{8} + n\pi$  or  $\theta = \frac{7\pi}{8} + n\pi$ , *n* is an integer
  - (B)  $\theta = \frac{\pi}{8} + 2n\pi$  or  $\theta = \frac{7\pi}{8} + 2n\pi$ , n is an integer
  - (C)  $\theta = \frac{2\pi}{3} + n\pi$  or  $\theta = \frac{4\pi}{3} + n\pi$ , n is an integer
  - (D)  $\theta = \frac{\pi}{4} + n\pi$  or  $\theta = \frac{3\pi}{4} + n\pi$ , *n* is an integer

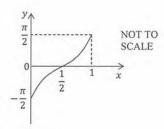
- 7. Which integral is obtained when the substitution  $x = \sin \theta$  is applied to  $\int \frac{x^2}{\sqrt{1-x^2}} dx$ ?
  - (A)  $\int \cos^2 \theta \, d\theta$
  - (B)  $\int \tan^2 \theta \, d\theta$
  - (C)  $\int \sin^2 \theta \, d\theta$
  - D)  $\int \sin^2 \theta \, \cos^2 \theta \, d\theta$
- 8. A particle is moving in simple harmonic motion with its velocity given by  $v^2 = 16(9 x^2)$ , where x is the displacement.

What is the amplitude A, and the period T, of the motion?

- (A)  $A = 3 \text{ and } T = \frac{\pi}{4}$
- (B)  $A = 3 \text{ and } T = \frac{\pi}{2}$
- (C)  $A = 4 \text{ and } T = \frac{\pi}{4}$
- (D)  $A = 4 \text{ and } T = \frac{\pi}{2}$
- 9. What is the term independent of x in the expansion of  $\left(x^3 + \frac{2}{x}\right)^{20}$ ?
  - (A)  $\binom{20}{10} 2^{10}$
  - (B)  $\binom{20}{5} 2^{15}$
  - (C)  $\binom{20}{4} 2^{16}$
  - (D)  $\binom{20}{5} 2^{25}$

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10. The diagram shows the graph of a function.



Which function does the graph represent?

- (A)  $y = -\cos^{-1}(2x 1)$
- (B)  $y = \sin^{-1}(2x 1)$
- (C)  $y = \sin^{-1}(x 1)$
- (D)  $y = -\cos^{-1}(x-1)$

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Page 5

# Section II

#### 60 Marks

#### Attempt questions 11-14

Answer each question in a SEPARATE writing booklet. Extra writing booklets are available.

In Questions 11-14, your responses should include relevant mathematical reasoning and/or calculations

Question 11 (15 Marks) Use a SEPARATE writing booklet.

(a) Let  $P(x) = x^3 - ax^2 + x$  be a polynomial, where a is a real number. When P(x) is divided by x - 3 the remainder is 12.

Express P(x) as a product of its factors.

(b) Solve 
$$\frac{5}{x-4} \ge 1$$

(c) Find the value of  $\lim_{x \to 0} \frac{3x \cos 4x}{\sin 2x}$ 

Show all necessary working.

(d) Use the substitution  $u = 1 + \sqrt{2x}$  to find

$$\int_{\frac{1}{2}}^{2} \frac{1}{1 + \sqrt{2x}} dx$$

(e) Find the exact value of  $\cos(2\cos^{-1}x + \sin^{-1}x)$  when  $x = \frac{1}{5}$ .

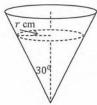
(f) Find  $\frac{d}{dx} \left( \tan^{-1} \frac{x}{3} \right)^2$  and hence find the exact value of  $\int_0^{\sqrt{3}} \frac{\tan^{-1} \frac{x}{3}}{x^2 + 9} dx$ 

# End of Question 11

JRAHS 2016 TRIAL MATHEMATICS EXTENSION 1
Page 6

#### QUESTION 12 (15 Marks) Use a SEPARATE writing booklet.

(a) In the figure below the angle between the axis and the slant edge of the right cone is 30°. Water is poured into the cone at a constant rate of 2 cm³ per second. At time t seconds, the radius of the water surface is r cm and the volume of water in the cone is V cm³.



- (i) Show that  $V = \frac{\sqrt{3}}{3}\pi r^3$ .
- (ii) Hence, find the rate at which r is changing when r = 2 cm.
- (b) The velocity of a particle moving in a straight line is given by

$$v^2 = -9x^2 + 18x + 27.$$

- Prove that the motion is simple harmonic.
- (ii) Hence find the centre of the motion.
- (iii) Find the maximum acceleration of the particle and state where it occurs. 2
- (c) Taking  $x = -\frac{\pi}{6}$  as a first approximation to the root of the equation  $2x + \cos x = 0$ , use Newton's method once to show that a second approximation to the root of the equation is  $\frac{-\pi 6\sqrt{3}}{30}$ .
- (d) An unbiased die is thrown 6 times. Calculate the probabilities that the six scores obtained
  - (i) will have a product which is an even number

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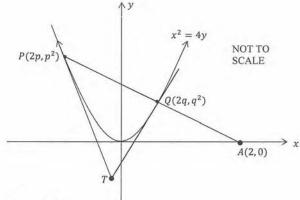
- (ii) will consist of exactly two 6's and four odd numbers
- 3

#### End of Question 12

JRAHS 2016 TRIAL MATHEMATICS EXTENSION 1
Page 7

## QUESTION 13 (15 Marks) Use a SEPARATE writing booklet.

(a) Let  $P(2p, p^2)$  and  $Q(2q, q^2)$  be two points on the parabola  $x^2 = 4y$ . The tangents to the parabola at P and Q intersect at T. The secant PQ passes through the point A(2, 0).



2

- (i) Show that p + q = pq.
- (ii) Assuming that the equation of the tangents at P and Q are  $y = px p^2$  and  $y = qx q^2$  respectively, determine the cartesian equation of the locus of T, including any restrictions.
- (b) The region enclosed by the curve  $y = \sin^{-1} x$  and the y -axis between x = 0 and  $x = \frac{\sqrt{3}}{2}$  is rotated about the y -axis to form a solid.

Find the exact volume of the solid of revolution formed.

(c) A manufacturer of metal pistons finds that on the average, 12% of the pistons are rejected because they are either oversize or undersize.

What is the probability that a batch of 10 pistons will contain no more than 2 rejects? 3 Express your answer to three decimal places.

## Question 13 continues on page 9

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				Page 8

Question 13 (continued)

(d) A household iron is cooling in a room where the temperature of the air is constant at 22°C.

After t minutes the temperature T of the iron is modelled by the equation  $T = 22 + Ae^{-kt}$ , where A and k are constants.

The initial temperature of the iron is 80°C and it cools to 60°C after 10 minutes.

- (i) Find the exact values of the constants A and k.
- (ii) How long will it take for the temperature of the iron to cool to 30°C? Give your answer to the nearest minute.

#### End of Question 13

JRAHS 2016 TRIAL MATHEMATICS EXTENSION 1

Page 9

2

2

QUESTION 14 (15 Marks) Use a SEPARATE writing booklet.

(a) Use mathematical induction to prove that for all positive integers n,

$$\sum_{r=1}^{n} r(r!) = (n+1)! - 1$$

- (b) The velocity of a particle moving in a straight line is given by  $\dot{x} = e^x + e^{-x}$ , where x in metres is the displacement from the origin. Initially the particle is at the origin.
  - Show that the time taken by the particle as a function of its displacement is given by

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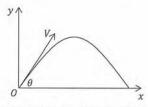
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$$t = \int \frac{e^x}{e^{2x} + 1} dx$$

ii) Hence, by using the substitution  $u = e^x$ , prove that

$$x = \ln\left(\tan\left(t + \frac{\pi}{4}\right)\right).$$

(c) A particle P is fired from the ground at t = 0 with initial velocity V from the origin, at an angle of θ to the horizontal.



Assume that the horizontal and vertical equations of motion for the particle is given by

$$x_P = Vt \cos \theta$$
 and (DO NOT  
 $y_P = Vt \sin \theta - \frac{1}{2}gt^2$  PROVE THESE)

(i) Show that the horizontal range of the projectile,  $R_P$ , is given by

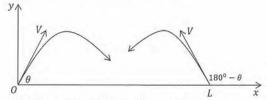
$$R_P = \frac{V^2 \sin 2a}{a}$$

#### Question 14 (c) continues on page 11

JRAHS 2016 TRIAL MATHEMATICS EXTENSION 1 Page 10

# Question 14 (c) (continued)

A second particle Q, is fired back towards the origin with velocity V from the ground at a distance of L metres to the **right** of the origin at time t=0, with an angle of  $(180-\theta)^0$  to the positive direction of the x-axis.



(ii) Show that if the particles collide, it will occur when

$$t = \frac{L}{2V\cos\theta}$$

(iii) For the particles to collide, it must occur while the particles are still in flight (i.e. above the ground).

Prove that, for the particles to collide in the air,

$$0 < L < \frac{4V^2 \cos \theta \sin \theta}{a}$$

End of paper

JRAHS 2016 TRIAL MATHEMATICS EXTENSION 1

Page 11

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8	Period = 72
$2\theta = 7\pi + 2n\pi$	
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Hence (A)	

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9. $(\chi^3 + \frac{2}{\chi})^{20}$			
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Extension 2 Suggested Solutions	Marks	Marker's Comments
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Extension 2 Suggested Solutions	Marks	Marker's Comments
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De 2; (66 AA BI) = 3(x 61	1	the right truck,

MATHEMATICS Extension 1: Question	n.[.3	
Suggested Solutions	Marks	Marker's Comments
a) $M = \frac{p'-q^2}{2p-2q}$		
$= \frac{(p-q)}{2} \frac{(p+q)}{2}$ $= \frac{p+q}{2}$ $y-p^2 = \frac{1}{2} (p+q) (p(-2p))$ goes through $A(2,0)$	1	well
0= 12 (r+q)2-pq	1	
b) $y = px - p^{2} - 0$ $y = qx - q^{2} - 0$ $(p-q) \times - (p^{2} - q^{2}) = 0$ $(p-q) \times - (p^{2} - q^{2}) = 0$ $(p-q) \times - (p-q) \times p+qy$ $\therefore y = q(p+q) - sub_{1} - 2$ $y = pq - q^{2} + q^{2}$ = pq $\Rightarrow T (p+q, pq)$		Students who substituted prop = po into X then Local difficulty finding

MATHEMATICS Extension 1 : Quest Suggested Solutions	ion. (.3	2_ Marker's Comments
Now ptq = pq		
x = p+q $y = pq$	1	
so y=x is locus	1	
Tangents meet outside of		
parabola		, , , ,
sub y=x 1-10 x12=44		equality will
x = 47C		not hold
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: x>4 and x ( 0		
lie a tricle parabola.	1	
y=x for x 74 or x c O		
p) 23 100 1 x		
TV3 7711		·DO NOT HEED
2 2		BUTE
$\mathcal{D}_3$		· Question clearly said y-axis
V= 77 /512 y dy		Students For
o Trs		1-correct
= 17 5 1/2 - 1/2 ros 2 y dy		region had
= 7 [ = y - + swry] F/3		to integral
= 71 [76+4] 13		get nerks

MATHEMATICS Extension 1: Question		1
Suggested Solutions	Marks	Marker's Comments
c) P(20+1ess rejects) 12 (0.12+011)10  P(2) + P(1) + P(0)		l for verogniling represent production
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+10(0.88)12	1	1 for Azulanu
= 0. Fal d) ()T= 22+ Ae-kt	1	
$t = 0  T = 80$ $80 = 22 + 40$ $0 = 10  T = 60$ $\frac{37}{78} = e^{-10R}$ $-10R = 1 - \frac{10}{29}  0R - \frac{1}{10} = \frac{19}{29}$ $k = 1 - \frac{19}{79}  0R - \frac{1}{10} = \frac{19}{29}$ $k = 1 - \frac{19}{79}  0R - \frac{1}{10} = \frac{19}{29}$ $k = 1 - \frac{19}{79}  0R - \frac{1}{10} = \frac{19}{29}$ $t = 30$ $30 = 22 + 57e$ $\frac{1}{10} = \frac{1}{79}$ $t = \frac{10}{10} = \frac{1}{79}$ $t = \frac{10}{10} = \frac{1}{79}$ $t = \frac{10}{10} = \frac{1}{79}$	l	well dove.
t-46.848 takes 470 ins		

MATHEMATICS: Question.!		
Suggested Solutions	Marks	Marker's Comments
[HS = 1   RHS = (1+1)! - 1   = 2!		Note: Students should define a correctly!
.: LHS = RHS .: The result is true for n=1 Assume result is the for n=k, k & Z	-O	
[HS=  (!) + 2(2!)+ b(b!) + (b+1)(b+1)!  =[(b+1)! -1] + (b+1)(b+1)! (By assumption) -  = (b+1)! [+ (b+1)] -	-0	
= (k+1)!(k+2) - ) = (k+2)! -   : If the result is true for n=k,	-(1)	
It is true for n=k+1  The result is true by Mathematical Induction.		

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Extension Suggested Solutions	Marks	Marker's Comment
b) i) x= e + e	-	more an extraor cost
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= 6 + 1	maggaran and an	annaharingan ana anakanderahilikh sarahbanahiliny terberahilikan
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		antikan serim kana menandak kenandan kenandan kenandan mengapa penjaga menjak arah kenanda.
11) let u=e* du .c*		
ii) let u=e du e du dx		
: 1 du		
t-) w+1		nterna er er en en er
to tant u +C		
t= tan (e*) + C	= 0	
Wen t=0, x=0		
		کانتان کانتان استان ا به مستان استان
The contract of the contract o	management between the second	
£ 7		AMERICANIS AND
t= tan (ex) - H	Andrew - and the second	·····································
fan (e') = + 74		a kina aliki wa malikiliki wa matao wa matao wa matao ka maliki wa matao ka ma matao ka ma matao ka matao ka m
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Extension   Suggested Solutions	Marks	Marker's Comments
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276.00		the trojectory of P.
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nce x=x, at t= 2vise and y= y, for all t	. Then Lad	P will collide

MATHEMATICS: Question	t	
Suggested Solutions	Marks	Marker's Comments
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: 0 < L < 8 V (a) 0 tano		
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or		
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