MUNSANG COLLEGE
2020 – 2021 Mock Examination
F.6 Mathematics Compulsory Part
Paper 1

Class : _______ Name : ____________________ Class Number : _____

*Please circle the initial of your subject teacher: CHF / CYL / HYC / MKL / WFL

Time allowed : 2 hours 15 minutes

Full mark : 105

This question-answer book consists of 28 printed pages.

INSTUCTIONS

1. After the announcement of the start of the examination, you should first write your name, class and class number in the space provided on this cover.

2. This paper consists of THREE sections, A(1), A(2) and B. Each section carries 35 marks.

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 name, class and class number 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 should be either exact or correct to 3 significant figures.

7. The diagrams in this paper are not necessarily drawn to scale.

	Marker's Use Only	**Examiner's Use Only**
	Marker No.	Examiner No.
Question No.	Marks	Marks
1 – 2		
3 – 4		
5		
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8		
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11		
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15		
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17		
18		
Total		

Section A(1) (35 marks)

1. Make n the subject of the formula $\frac{5m-n}{2}=\frac{n}{3}+1$.

(3 marks)

$$\frac{5m-n}{2} = \frac{n}{3}+1$$

$3(5m-n) = 2n+6$ 1M

$15m - 6 = 2n+3n$ 1M

$n = \frac{15m-6}{5}$ 1A

$= 3m - \frac{6}{5}$

2. Simplify $\frac{(x^5y^{-3})^2}{y^7}$ and express your answer with positive indices.

(3 marks)

$\frac{(x^5y^{-3})^2}{y^7} = \frac{x^{10}y^{-6}}{y^7}$ 1M

$= x^{10}y^{-6-7}$

$= x^{10}y^{-13}$ 1M

$= \frac{x^{10}}{y^{13}}$ 1A

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3. Factorize $2x^3 - 8x(y-z)^2$. (3 marks)

$2x^3 - 8x(y-z)^2$

$= 2x[x^2 - 4(y-z)^2]$ 1M

$= 2x[x^2 - (2y-2z)^2]$ 1A

$= 2x(x+2y-2z)(x-2y+2z)$ 1A

4. There are certain numbers of boys and girls in a group. If 4 boys leave the group, then the ratio of the number of boys to the number of girls is 2 : 1. If 1 more boy and 1 more girl join the group, then the ratio of the number of boys to the number of girls is 3 : 1. Find the ratio of the original number of boys to the original number of girls in the group.

(4 marks)

Let b and g be the original numbers of boys and girls in the group respectively.

$\frac{b-4}{g} = \frac{2}{1} \rightarrow b = 2g+4$ ——(1) 1A

$\frac{b+1}{g+1} = \frac{3}{1} \rightarrow b = 3g+2$ ——(2) 1A

From (1) and (2) $2g+4 = 3g+2$

$\therefore g = 2$ and $b = 8$ 1A

The required ratio $= 8 : 2$

$= 4 : 1$ 1A

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5. Friderich wants to buy 25 identical gifts from a gift shop. His budget is \$1000 and the marked price of each gift is \$48. If Friderich can get one gift free of charge for every purchase of five gifts, does he have enough budget to buy all the 25 gifts? Explain your answer.

(4 marks)

$\frac{\$1000}{\$48} = 20\frac{5}{6}$

∴ Friderich can buy 20 gifts without any offer 1M

If Friderich can get one free gift for every purchase of 5 gifts, he can get

$\frac{20}{5} = 4$ gifts in addition 1M

As a total, he can buy 24 gifts by \$1000 under the special offer with \$40 left. 1M

∴ Friderich does not have enough budget to buy all 25 gifts. 1A

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6. (a) Find the range of values of x which satisfy both $2(3x-2)<11$ and $\frac{x-5}{2} \le \frac{4x}{3}$.

(b) Find the number of integers satisfying both inequalities in (a).

(4 marks)

(a) $2(3x-2) < 11$

$6x - 4 < 11$

$x < \frac{5}{2}$ 1A

$\frac{x-5}{2} \le \frac{4x}{3}$

$3x - 15 \le 8x$

$-15 \le 5x$ 1M

$x \ge -3$

The required range is $-3 \le x < \frac{5}{2}$ 1A

(b) Integers satisfying the inequalities are

$-3, -2, -1, 0, 1, 2$.

Altogether there are 6 such integers. 1A

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7. The coordinates of points P and Q are $(-4, -2)$ and $(1, 3)$ respectively. P is rotated anti-clockwise about the origin through 90° to P'. Q is translated rightwards by 8 units to the point Q'.

(a) Write down the coordinates of P' and Q'.

(b) Prove that PQ is parallel to $P'Q'$.

(4 marks)

(a) $P' = (2, -4)$ 1A

$Q' = (9, 3)$ 1A

(b) Slope of $PQ = \frac{-2-3}{-4-1} = 1$

1M

Slope of $P'Q' = \frac{-4-3}{2-9} = 1$

$\therefore$ Slope of PQ = Slope of $P'Q'$

$\therefore$ $PQ \parallel P'Q'$ 1 f.t.

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8. In Figure 1, BD is a diameter of the circle $ABCD$. If $\angle ACD = 54°$, find the ratio of the arc lengths $\overset{\frown}{AB} : \overset{\frown}{AD}$.

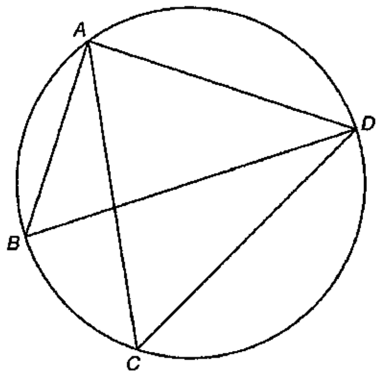

Figure 1

(5 marks)

BD is a diameter.

$\therefore \angle BAD = 90°$ ($\angle$ in semicircle) 1A

$\angle BAD + \angle ABD + \angle BDA = 180°$ ($\angle$ sum of $\triangle$)

$\therefore \angle ABD + \angle BDA = 90°$

$\angle ABD = \angle ACD$ ($\angle$s in the same segment) 1A

$= 54°$

$\therefore \angle BDA = 36°$ 1A

$\overset{\frown}{AB} : \overset{\frown}{AD} = \angle BDA : \angle ABD$ (arcs prop to $\angle$s at O^{ce}) 1M

$= 36° : 54°$

$= 2 : 3$ 1A

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9. The following table shows the numbers of books read by 40 students in a certain week.

Number of books read	1	2	3	4
Number of students	x	8	9	y

It is given that x and y are positive integers.

(a) Find the least possible value and the greatest possible value of the mean of the distribution.

(b) Leonhard has the following claim.
'If the mode of the distribution is 4, the median of the distribution must not be less than 3.'
Is his claim correct? Explain your answer.

(5 marks)

(a) Least possible mean $= \dfrac{22(1)+8(2)+9(3)+1(4)}{40}$

$= 1.725$ 1A

Greatest possible mean $= \dfrac{1(1)+8(2)+9(3)+22(4)}{40}$

$= 3.3$ 1A

(b) The mode $= 4$ $\therefore y \geq 12$ 1A

$x \leq 11$

The median $= \dfrac{20\text{th datum} + 21\text{st datum}}{2}$

≥ 3 accordingly 1

$\therefore$ Leonhard is correct 1A

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Section A(2) (35 marks)

10. The stem-and-leaf diagram below shows the test scores of 30 students in a class..

Stem (tens)	Leaf (units)
1	a
2	
3	1 3
4	5 6 9
5	0 1 2 3 7 9 9
6	0 0 3 4 4 6 6 9
7	1 b 3 5 5 5
8	3 6
9	2

(a) If the range and the inter-quartile range of these scores are 81 and 22 respectively, find the values of a and b. (3 marks)

(b) Due to a mistake in recording, the score of a student should be 11 instead of 71.

(i) What is the change in the mean of the test scores?

(ii) Bernhard claims that for the two statistical measures in (a), correcting the score from 71 to 11 will only affect the value of the inter-quartile range. Do you agree? Explain your answer. (5 marks)

(a) Range $= 92-(10+a)=81$ either 1M

$\therefore a=1$ 1A

Interquartile range $=(70+b)-51=22$

$\therefore b=3$ 1A

(b) (i) Let m be the original mean

Change $=\dfrac{(30m-71+11)-30m}{30}=-2$ 1M

The mean decreases by 2. 1A

(ii) The corrected datum does not affect the largest and the smallest data, the range remain unchanged. 1A

The original Q_3 and Q_1 are 73 and 51 while the corrected Q_3 and Q_1 are 73 and 50,

the interquartile range is changed. 1A

The claim is correct. 1A

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11. The cost of printing n copies of a brochure for a company is $\$C$. It is known that C is partly constant and partly varies as $\sqrt{n}$.

When $n = 10\,000$, $C = 212\,000$ and when $n = 40\,000$, $C = 224\,000$.

(a) Find the cost of printing 62 500 copies of that brochure. (4 marks)

(b) After a careful investigation, the company decides to increase the number of copies of brochure printed from 62 500 to 250 000. The company claims that the extra cost of printing the brochures is less than \$50 000. Do you agree? Explain your answer. (2 marks)

Let $C = k_1 + k_2\sqrt{n}$ 1A

where k_1, k_2 are non-zero constants

When $n = 10\,000$, $C = 212\,000$

$212000 = k_1 + k_2\sqrt{10\,000}$

$k_1 + 100k_2 = 212\,000$ —(1)

1M (either)

When $n = 40\,000$, $C = 224\,000$

$224\,000 = k_1 + k_2\sqrt{40\,000}$

$k_1 + 200k_2 = 224\,000$ — (2)

(2) − (1) $100k_2 = 12000$

$k_2 = 120$

Subst into (1) $k_1 = 200\,000$

$\therefore$ $C = 200\,000 + 120\sqrt{n}$ 1A

When $n = 62500$,

$C = 200\,000 + 120\sqrt{62\,500} = 230\,000$

The required cost is \$230 000 1A

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(b) When $n = 250\,000$

$C = 200\,000 + 120\sqrt{250\,000} = 260\,000$

The extra cost $= 260\,000 - 230\,000$ 1M

$= 30\,000$

$< 50\,000$

The claim is agreed. 1A

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12. Figure 2(a) shows a right conical vessel of base radius 9 cm. The curved surface area of the vessel is 135π cm^2. The vessel is now fully filled with water.

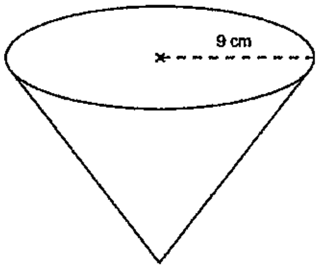

Figure 2(a)

(a) Find

(i) the height of the vessel,

(ii) the volume of the vessel in terms of π.

(4 marks)

(b) In Figure 2(b), the water in the vessel is poured into three identical paper cups which are similar in shape to the vessel.

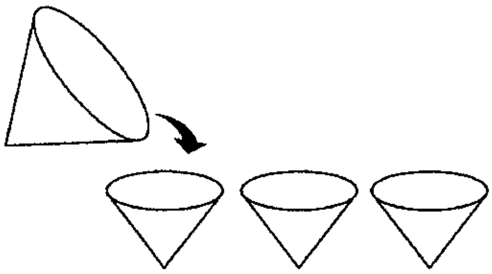

Figure 2(b)

If the water just fills up the three cups without overflow, find the base radius of the paper cup.

(~~6~~ 2 marks)

(a) (i) Let h cm be the height of the vessel

$\pi \cdot 9 \cdot \sqrt{9^2 + h^2} = 135\pi$ 1M

$81 + h^2 = 225$

$h^2 = 144$

$h = 12$

$\therefore$ The height of the vessel is 12 cm. 1A

(ii) The volume $= \frac{1}{3}\pi(9)^2(12)$ 1M

$= 324\pi$ cm^3 1A

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(b) Let r cm be the base radius of the paper cup.

$\frac{1}{3} = \left(\frac{r}{9}\right)^3$ 1A

$r^3 = 243$

$r = 6.24$ (cor to 3 sig fig)

The base radius of the paper cup is 6.24 cm. 1A

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13. The cubic polynomial $f(x)$ is divisible by $x-2$. When $f(x)$ is divided by x^2-4, the remainder is $4x+k$, where k is a constant.

(a) Find the value of k. (3 marks)

(b) It is given that $f(x)$ is also divisible by $x+4$. When $f(x)$ is divided by x, the remainder is 40. Georg claims that all the roots of the equation $f(x)=0$ are integers. Do you agree? Explain your answer. (4 marks)

(a) $f(x) = (x^2-4)\,q(x) + 4x + k$ 1A

where $q(x)$ is a polynomial

$f(2) = 0$

$(2^2-4)\,q(2) + 4(2) + k = 0$ 1M

$k = -8$ 1A

(b) $f(x)$ is a cubic polynomial.

Let $f(x) = (x-2)(x+4)(ax+b)$ 1M for 3 factors

for a, b constants.

$f(0) = 40$ i.e. $(-2)(4)(b) = 40$

$b = -5$ 1A

From (a)

$f(x) = (x^2-4)\,q(x) + 4x - 8$

$(x-2)(x+4)(ax-5) = (x^2-4)\,q(x) + 4x - 8$

Subst $x = -2$

$(-2-2)(-2+4)(-2a-5) = [(-2)^2-4]\,q(-2) + 4(-2) - 8$

$16a + 40 = -16$

$a = -\dfrac{7}{2}$ 1A

$f(x) = (x-2)(x+4)(-\frac{7}{2}x - 5)$

Roots of $f(x)=0$ are $2, -4, -\dfrac{10}{7}$

They are not all integers

The claim is disagreed. 1A f.t.

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14. In Figure 3, the straight line L: $3x - 5y + 15 = 0$ cuts the x-axis and the y-axis at A and B respectively.

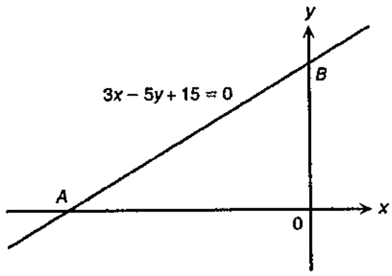

Figure 3

(a) Find the coordinates of A and B. (2 marks)

(b) P is a moving point on the coordinate plane such that $AP \perp BP$. Denote the locus of P by Γ.

(i) Does the origin O lie on Γ? Explain your answer.

(ii) Describe the geometric relation between the line segment AB and Γ.

(iii) Find the equation of Γ.

(6 marks)

(a) When $y=0$, $x=-5$

$\therefore A=(-5,0)$ 1A

When $x=0$, $y=3$

$\therefore B=(0,3)$ 1A

(b) (i) $\because OA \perp OB$ $\therefore$ O lies on Γ. 1A

(ii) Γ is a circle 1A

with AB as a diameter of Γ. 1A

(iii) Let $P=(x,y)$

Slope of AP · Slope of BP $=-1$

$$\frac{y-0}{x+5}\cdot\frac{y-3}{x-0}=-1$$ 1M

$$y^2-3y=-x^2-5x$$

$$x^2+y^2+5x-3y=0$$ 1M + 1A

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Section B (35 marks)

15. There are 8 kittens and 4 puppies in a garden. A photo is taken with 5 of the cubs being randomly selected in the garden. Find the probabilities that

(a) 3 kittens and 2 puppies are selected, (2 marks)

(b) 3 kittens and 2 puppies are selected provided that there is at least 1 puppy selected. (4 marks)

(a) The required probability

$$= \frac{C^8_3 C^4_2}{C^{12}_5}$$ 1A for numerator

$$= \frac{336}{792} = \frac{14}{33} = 0.424$$ 1A

(b) Prob (at least 1 puppy selected)

$$= 1 - \frac{C^8_5}{C^{12}_5}$$ 1M

$$= \frac{92}{99} = 0.929$$ 1A

Required probability

$$= \frac{14/33}{92/99}$$ 1M

$$= \frac{21}{46} = 0.457$$ 1A

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16. The yearly profit of Évariste & Co. in 2012 was $\$P$. The yearly profit increases at a constant rate of $r\%$ per year. Let $T(n)$ denote the yearly profit of Évariste & Co. in the nth year after 2012.

(a) It is given that the yearly profits in 2014 and 2016 were \$1 028 500 and \$1 244 485 respectively. Find the values of P and r. (4 marks)

(b) Find the total yearly profit of Évariste & Co. from 2012 to 2019. (2 marks)

(c) In which year will the total yearly profit of Évariste & Co. first exceed 5×10^7? (3 marks)

(a) $T(2)$: $P(1+r\%)^2 = 1028500$ —(1) 1M

$T(4)$: $P(1+r\%)^4 = 1244485$ —(2)

$\frac{(2)}{(1)}$ $(1+r\%)^2 = 1.21$ 1M

$r = 10$ 1A

Subst $r=10$ into (1)

$P(1.1)^2 = 1028500$

$P = 850000$ 1A

(b) Total yearly profit from 2012 to 2019

$= T(0) + T(1) + \cdots + T(7)$

$= \frac{850000(1.1^8 - 1)}{1.1 - 1}$ 1M

$= 9720504.885$

$= \$9720000$ 1A

(c) $\frac{850000(1.1^{n+1} - 1)}{1.1 - 1} > 5 \times 10^7$ 1A

$1.1^{n+1} > 6.882$

$n+1 > \frac{\log 6.882}{\log 1.1} = 20.2$ 1M

∴ In 2032, the total yearly profit first exceed 5×10^7. 1A

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17. Let $f(x)=\frac{1}{k}\left[x^2+(2k-6)x-5k+9\right]$, where k is a constant with $\frac{1}{2}\le k\le\frac{3}{2}$ and the point (3, 1) be A.

(a) Prove that A lies on the graph of $y=f(x)$. (1 mark)

(b) The graph of $y=g(x)$ is obtained by reflecting the graph of $y=f(x)$ with respect to the y-axis and then translating the resulting graph downwards by 2 units.

Let M be the vertex of the graph of $y=g(x)$. Denote the point $(1, -9)$ by N.

(i) By the method of completing the square, express the coordinates of M in terms of k.

(ii) Find k, in surd form, such that the circumcentre of ΔANM lies on AN.

(iii) It is known that he graph of $y=g(x)$ passes through the same point P for all positive constant k. Let Q be the vertex of the graph of $y=g(x)$ such that the circumcentre C of ΔANQ lies on AN. Henri claims that P, Q and C are collinear.

Do you agree? Explain your answer. (10 marks)

(a) $f(3)=\frac{1}{k}\left[3^2+(2k-6)(3)-5k+9\right]=1$

$\therefore$ The graph of $y=f(x)$ passes through $A(3,1)$. 1A

(b)(i) $g(x)=f(-x)-2$ 1M

$=\frac{1}{k}\left[(-x)^2+(2k-6)(-x)-5k+9\right]-2$

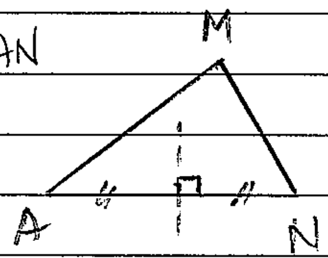
$=\frac{1}{k}\{x^2-(2k-6)x+(k-3)^2-(k-3)^2-5k+9\}-2$ 1M

$=\frac{1}{k}\{[x-(k-3)]^2-k^2+k\}-2$

$=\frac{1}{k}[x-(k-3)]^2-k-1$

$\therefore M=(k-3,-k-1)$ 1A

(ii) Circumcentre of ΔANM lies on AN if $\angle AMN=90^\circ$.



Slope of AM $\cdot$ Slope of MN $=-1$

$\frac{1+(k+1)}{3-(k-3)}\cdot\frac{-9+(k+1)}{1-(k-3)}=-1$ 1M

$k^2-8k+4=0$

$k=4+\sqrt{12}$ (rej.) or $4-\sqrt{12}$

$\therefore k=4-2\sqrt{3}$ 1A

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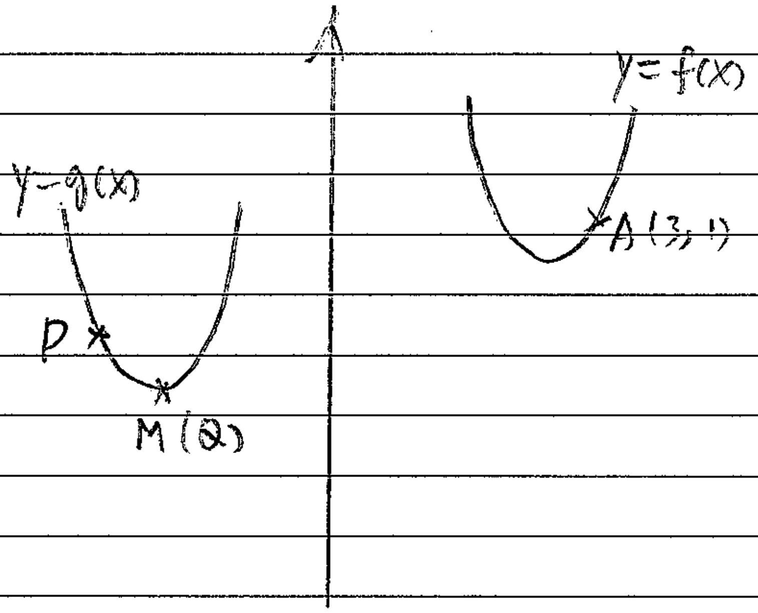
(b) (iii)



$P = (-3, -1)$ 1A

$Q = (4 - 2\sqrt{3} - 3, -4 + 2\sqrt{3} - 1) = (1 - 2\sqrt{3}, -5 + 2\sqrt{3})$ 1A

$C = \left(\frac{3+1}{2}, \frac{1-9}{2}\right) = (2, -4)$ 1A

Slope of $PC = \frac{-1+4}{-3-2} = -\frac{3}{5}$

either Two

Slope of $PQ = \frac{-5+2\sqrt{3}+1}{1-2\sqrt{3}+3} = \frac{-4+2\sqrt{3}}{4-2\sqrt{3}} = -1$ 1M

Slope of $QC = \frac{-5+2\sqrt{3}+4}{1-2\sqrt{3}-2} = \frac{-1+2\sqrt{3}}{-1-2\sqrt{3}} = \frac{-13+4\sqrt{3}}{11}$

$\because$ Slopes are not equal

P, Q, C are not collinear 1A f.t.

The claim is disagreed.

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18. In Figure 4(a), *PTQSR* is a paper card in the shape of a concave pentagon. It is given that $PT = 10$ cm, $TQ = SQ = 8$ cm, $\angle TPR = 96°$ and $\angle PTQ = 38°$. *PS* and *TR* are straight lines intersecting at *Q*.

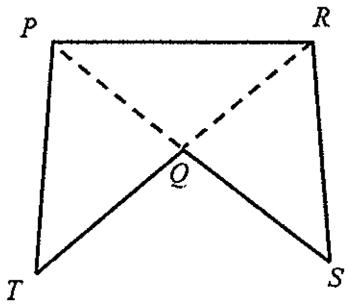


Figure 4(a)

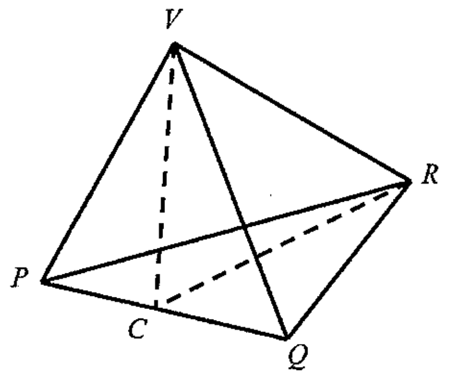


Figure 4(b)

(a) (i) Find the lengths of *PR* and *QR*.

(ii) Find $\angle QPR$.

(5 marks)

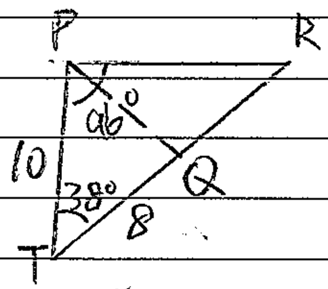
(b) The paper card in Figure 4(a) is folded along *PQ* and *QR* such that *T* and *S* meet at a point *V* as shown n Figure 4(b). Let *C* be a point lying on *PQ* satisfying that *VC* is perpendicular to *PQ*.

(i) Find the length of *CR*.

(ii) David claims that $\angle VCR$ is the angle between the face *VPQ* and the face *PQR*. Do you agree? Explain your answer.

(4 marks)

(a) Consider ΔPTR.



$\frac{PR}{\sin 38°} = \frac{10}{\sin(180° - 96° - 38°)}$ 1M

$PR \approx 8.558701674$

≈ 8.56 cm 1A

$TR^2 = 10^2 + PR^2 - 2 \cdot 10 \cdot PR \cos 96°$ 1M

≈ 191.14393301552

$QR = TR - 8 \approx 5.825481294 \approx 5.83$ cm 1A

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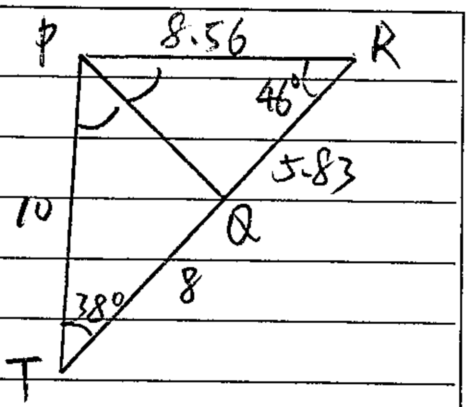
(a)(ii) Consider ΔPTQ

$PQ^2 = 10^2 + 8^2 - 2(10)(8)\cos 38^\circ$

$\approx 37.9182794229\,2$



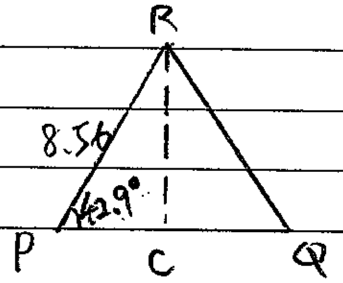
Consider ΔPQR

$\dfrac{QR}{\sin\angle QPR} = \dfrac{PQ}{\sin 46^\circ}$

~~$\sin\angle QPR \approx 0.68052109228$~~

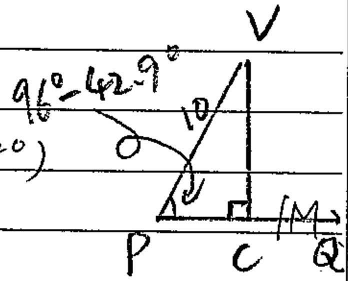
$\angle QPR \approx 42.8843765103 8^\circ \approx 42.9^\circ$ 1A

(b) (i) In ΔPQR



$PC = ?$

In ΔVPC,



$PC \approx 10\cos(96^\circ - 42.8843765103 8^\circ)$

$\approx 6.0020214 41$

In ΔPQR

$CR^2 = PR^2 + PC^2 - 2\,PR \cdot PC\cos\angle CPR$

$\approx 33.9958271888 4$

$CR \approx 5.8305940682 6 \approx 5.83\text{ cm}$ 1A

(ii) $CR^2 + CP^2 \approx 70.020$

$PR^2 \approx 73.251$

$CR^2 + CP^2 \cdot PR^2$ 1M

$\therefore \angle PCR$ is not a right angle.

$\therefore \angle VCR$ is not the angle between the faces.

The claim is not agreed. 1A f.t.

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Answers written in the margins will not be marked.

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