
AS & A Level Mathematics (9709) Paper 4
[Mechanics]

Exam Series: May/Jun 2015 – Oct/Nov 2022

Format Type A:

Answers to all questions are provided as an appendix



Introduction

Each Topical Past Paper Questions Compilation contains a comprehensive collection of hundreds of questions and corresponding answer schemes, presented in worksheet format. The questions are carefully arranged according to their respective chapters and topics, which align with the latest IGCSE or AS/A Level subject content. Here are the key features of these resources:

1. The workbook covers a wide range of topics, which are organized according to the latest syllabus content for Cambridge IGCSE or AS/A Level exams.
2. Each topic includes numerous questions, allowing students to practice and reinforce their understanding of key concepts and skills.
3. The questions are accompanied by detailed answer schemes, which provide clear explanations and guidance for students to improve their performance.
4. The workbook's format is user-friendly, with worksheets that are easy to read and navigate.
5. This workbook is an ideal resource for students who want to familiarize themselves with the types of questions that may appear in their exams and to develop their problem-solving and analytical skills.

Overall, Topical Past Paper Questions Workbooks are a valuable tool for students preparing for IGCSE or AS/A level exams, providing them with the opportunity to practice and refine their knowledge and skills in a structured and comprehensive manner. To provide a clearer description of this book's specifications, here are some key details:

- Title: Cambridge AS & A Level Mathematics (9709) Paper 4 Topical Past Paper Questions
- Subtitle: Exam Practice Worksheets With Answer Scheme
- Examination board: Cambridge Assessment International Education (CAIE)
- Subject code: 9709
- Years covered: May/Jun 2015 – Oct/Nov 2022
- Paper: 4 [Mechanics]
- Number of pages: 690
- Number of questions: 337

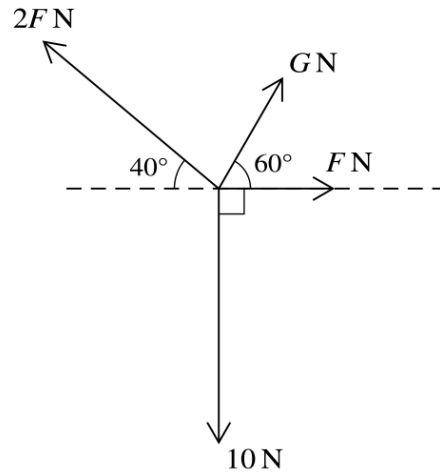
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Chapter 1

Forces and equilibrium

1. 9709_m22_qp_42 Q: 5



Four coplanar forces act at a point. The magnitudes of the forces are 10 N , $F\text{ N}$, $G\text{ N}$ and $2F\text{ N}$. The directions of the forces are as shown in the diagram.

- (a) Given that the forces are in equilibrium, find the values of F and G . [5]

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- (b) Given instead that $F = 3$, find the value of G for which the resultant of the forces is perpendicular to the 10 N force. [2]

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Find the greatest value of X for which the crate remains at rest. [5]

[illegible]

[6]

This image shows a full page of white paper with horizontal dashed lines, typical of primary school handwriting practice paper. The lines are evenly spaced and run across the width of the page. There are no margins, text, or other markings on the paper.

A diagram showing a horizontal line with points A and B. Two lines, AC and BC, connect A and B to a point C below the line. The length of AC is 0.8 m and the length of BC is 0.6 m. A right-angle symbol is at point C. A horizontal arrow labeled $F\text{ N}$ points to the right from point C. Below point C is a black rectangular block labeled 10 kg.

(a) In the case where $F = 20$, find the tensions in each of the strings. [5]

[illegible]

[illegible]

Find the values of P and Q . [5]

This image shows a full page of white paper with horizontal ruling lines. The lines are evenly spaced and extend across the width of the page, providing a template for handwriting practice or general writing. There are no margins, text, or other markings on the page.

A diagram of a sphere of mass 4 kg and radius 0.2 m . The sphere is pivoted at point A on its top surface. A vertical dashed line passes through A and the center C . A solid line connects A to C , forming an angle of 25° with the vertical dashed line.

Find the tension in the string and the magnitude of the normal reaction of the wire on the ring. [6]

This image shows a single sheet of white paper with horizontal ruling lines. The lines are evenly spaced and extend across the width of the page. There are no margins, text, or other markings on the paper.

(a) Given that the component of the resultant force in the x -direction is zero, find α , and hence find the magnitude of the resultant force. [4]

This image shows a full page of white paper with horizontal dashed lines, typical of primary-ruled notebook paper. The lines are evenly spaced and run across the width of the page. There are no margins, text, or other markings on the paper.

[illegible]

Appendix A

Answers

1. 9709_m22_ms_42 Q: 5

Question	Answer	Marks	Guidance
(a)	Attempt to resolve vertically or horizontally	M1	Correct number of terms.
	$G \sin 60^\circ + 2F \sin 40^\circ - 10 = 0$	A1	Correct resolution vertically.
	$F + G \cos 60^\circ - 2F \cos 40^\circ = 0$	A1	Correct resolution horizontally.
	Attempt to solve simultaneously for F or G	M1	From equations with 3 relevant terms in each
	$F = 4.53, G = 4.82$	A1	For both correct.
		5	
(b)	$G \sin 60^\circ + 2 \times 3 \sin 40^\circ - 10 = 0$	M1	Resolve forces parallel to the 10 N force and equate this expression to zero, 3 terms.
	$G = 7.09$ to 3 sf	A1	
		2	

2. 9709_s22_ms_41 Q: 3

Question	Answer	Marks	Guidance
	For attempt at resolving horizontally or vertically	M1	Allow sin/cos mix. Allow sign error. Allow g missing. Correct number of terms.
	$R = 300g - 0.28X$ or $R = 300g - X \sin 16.3$	A1	$\alpha = 16.26 \dots$
	$0.96X - F = 0$ or $0.96X - 0.5(300g - X \sin \alpha) = 0$ Or $X \cos 16.3 - F = 0$ or $X \cos 16.3 - 0.5(300g - X \sin \alpha) = 0$	A1	Or using <i>their</i> F
	Use of $F = 0.5R$	M1	Use to get an equation in X only. Allow sin/cos mix. Allow sign error. Allow g missing. Must be from 2 term R , which is a linear combination of $300(g)$ and a component of X
	$X = 1360$ [1363.63...]	A1	
		5	

3. 9709_s22_ms_41 Q: 4

Question	Answer	Marks	Guidance
	Attempt to resolve in any direction	M1	For resolving. Allow sin/cos mix. Allow sign error. Correct number of terms.
	$F \cos \alpha - 20 \cos 40 - 100 \sin 20 = 0$ [$F \cos \alpha = 15.320... + 34.202... = 49.5229...$]	A1	
	$F \sin \alpha + 20 \sin 40 - 100 \cos 20 = 0$ [$F \sin \alpha = 93.969... - 12.855... = 81.1135...$]	A1	
	$F = \sqrt{(49.5229...)^2 + (81.1135...)^2}$	M1	OE; Attempt to solve for F ; one term missing in total
	$\alpha = \tan^{-1}\left(\frac{81.1135...}{49.5229...}\right)$	M1	OE; Attempt to solve for α ; one term missing in total
	$F = 95(.0), \alpha = 58.6$	A1	$F = 95.0364...$ and $\alpha = 58.5943...$
Alternative mark scheme for question 4: For candidates who use cosine and/or sine rule			
	Attempt at cosine rule from triangle of forces	M1	Must use lengths 100 and 20 with a suitable angle
	$F^2 = 100^2 + 20^2 - 2 \times 100 \times 20 \cos 70$	A1	Correct
	$F = 95[.0]$	A1	
	$\frac{95.0364}{\sin 70} = \frac{20}{\sin \beta}$ OR $\frac{95.0364}{\sin 70} = \frac{100}{\sin \gamma}$	M1	Attempt at sin rule
		A1	where $\beta = (70 - \alpha)$ where $\gamma = (40 + \alpha)$
	$\alpha = 58.6$	A1	$\alpha = 58.5943...$

Question	Answer	Marks	Guidance
Alternative mark scheme for question 4: For candidates who resolve in other directions			
	Attempt to resolve (e.g. parallel or perpendicular to 100 N)	M1	For resolving. Allow sin/cos mix. Allow sign error. Correct number of terms.
	$F \sin(\alpha + 20) + 20 \sin 20 - 100 = 0$ [$F \sin(\alpha + 20) = 93.159...$]	A1	
	$F \cos(\alpha + 20) - 20 \cos 20 = 0$ [$F \cos(\alpha + 20) = 18.793...$]	A1	
	$F = \sqrt{93.159...^2 + 18.793^2}$	M1	OE; Attempt to solve for F ; one term missing in total
	$\alpha = \tan^{-1}\left(\frac{93.159...}{18.793...}\right) - 20$	M1	OE; Attempt to solve for α ; one term missing in total
	$F = 95[.0], \alpha = 58.6$	A1	$F = 95.0364...$ and $\alpha = 58.5943...$
		6	

4. 9709_s22_ms_42 Q: 2

Question	Answer	Marks	Guidance
	Resolving either direction	M1	3 terms; allow sign errors and allow sin/cos mix
	$(X =) \pm (20 \cos 60 - 14 - 16 \cos 50) \quad [= \mp 14.2846 \dots]$	A1	
	$(Y =) \pm (60 - 20 \sin 60 - 16 \sin 50) \quad [= \pm 30.42278 \dots]$	A1	
	$R = \sqrt{(14.2846 \dots)^2 + (30.42278 \dots)^2}$	M1	Attempt to solve for R ; one missing term in total
	$\theta = \tan^{-1} \left(\frac{30.42278 \dots}{14.2846 \dots} \right) [= \tan^{-1} (2.1297 \dots)]$ OR $\alpha = \tan^{-1} \left(\frac{14.2846 \dots}{30.42278 \dots} \right) [= \tan^{-1} (0.4596 \dots)]$	M1	Attempt to solve for θ or α ; one missing term in total
	$R = 33.6 \text{ N}$ Direction is 64.8° above the 14 N force or 25.2° above the negative x -axis or 25.2° left of the 60 N force or bearing 335° or 115° anticlockwise from the positive x -axis	A1	Both correct. OE; allow 64.9 , 25.1 Giving an angle only is insufficient. Direction may be seen on a diagram, with minimum of arrow on resultant. Arrows on both components only is A0 as it doesn't show the direction of the resultant. However the direction is stated, it must be able to be drawn uniquely.
		6	

5. 9709_s22_ms_42 Q: 5

Question	Answer	Marks	Guidance
	Attempt at resolving parallel to the plane	*M1	3 terms. Allow sign errors, sin/cos mix. Allow g missing, otherwise dimensionally correct.
	$65 \cos 36 = 12g \times \sin 24 + F$	A1	$F = 3.777707 \dots$
	Attempt at resolving perpendicular to the plane	*M1	3 terms. Allow sign errors, sin/cos mix. Allow g missing, otherwise dimensionally correct.
	$12g \times \cos 24 = R + 65 \sin 36$	A1	$R = 71.419 \dots$
	Use $F = \mu R$ $\left[\mu = \frac{65 \cos 36 - 12g \times \sin 24}{12g \times \cos 24 - 65 \sin 36} = \frac{52.586 - 48.808}{109.625 - 38.206} = \frac{3.777 \dots}{71.419 \dots} \right]$	DM1	To get an equation in μ only. Dependent on two previous M marks. Allow g missing
	$\mu = 0.0529$	A1	Allow AWRT 0.053 Do not accept fractional equivalent.
		6	

6. 9709_s22_ms_43 Q: 4

Question	Answer	Marks	Guidance
(a)	$T_A \times 0.8 - T_B \times 0.6 - 20 = 0$ or $T_A \times 0.6 + T_B \times 0.8 - 10g = 0$	M1	Resolving horizontally or vertically
	$T_A \times 0.8 - T_B \times 0.6 - 20 = 0$	A1	
	$T_A \times 0.6 + T_B \times 0.8 - 10g = 0$	A1	
	$0.8T_A - \frac{0.6(10g - 0.6T_A)}{0.8} = 20 \rightarrow T_A = \dots$	M1	Attempt to solve simultaneously
	$T_A = 76 \text{ N}, T_B = 68 \text{ N}$	A1	
		5	

Question	Answer	Marks	Guidance
(b)	$T_A \times 0.6 - 10g = 0 \Rightarrow T_A = \frac{500}{3}$	B1	From using $T_B = 0$
	$T_A \times 0.8 - F = 0$	M1	
	$F = \frac{400}{3}$	A1	Allow $F = 133$ to 3 s.f.
		3	

7. 9709_w22_ms_41 Q: 1

Question	Answer	Marks	Guidance
	Attempt at resolving horizontally or vertically	M1	Allow sign errors, allow sin/cos mix. 3 terms.
	$P \cos 25 = 22 + 16 \cos 55$	A1	
	$Q + 16 \sin 55 = P \sin 25$	A1	Allow <i>their P</i> .
	Attempt to solve for P or Q	M1	No missing/extra terms.
	$P = 34.4 \quad Q = 1.43$	A1	$P = 34.40025941, Q = 1.431745128$.
		5	

8. 9709_w22_ms_42 Q: 3

Question	Answer	Marks	Guidance
	Attempt to resolve either direction	M1	Correct number of terms. Allow sin/cos mix. Allow sign errors. Allow g missing.
	$0.3g + T \cos \alpha^\circ - 4 \sin 60^\circ = 0 \quad (T \cos \alpha^\circ = 0.464\dots)$	A1	OE
	$T \sin \alpha^\circ - 4 \cos 60^\circ = 0 \quad (T \sin \alpha^\circ = 2)$	A1	OE If the two T s are different, award maximum A1A0 unless subsequently stated that the two T s are the same.
	$\alpha = \tan^{-1} \left(\frac{4 \cos 60^\circ}{4 \sin 60^\circ - 0.3g} \right) = \tan^{-1} \left(\frac{2}{0.464\dots} \right)$	M1	Attempt to solve for α . No missing/extra terms. Allow g missing. Must get to ' $\alpha =$ '.
	$T = \frac{4 \cos 60^\circ}{\sin(\text{their } \alpha)} = \sqrt{(4 \cos 60^\circ)^2 + (4 \sin 60^\circ - 0.3g)^2} = \sqrt{2^2 + (0.464\dots)^2}$	M1	OE Attempt to solve for T . No missing/extra terms. Allow g missing. Must get to ' $T =$ '.
	Tension = 2.05 N $\alpha = 76.9$	A1	For both AWRT 2.05, 76.9 (Tension = 2.05314... N $\alpha = 76.9356\dots$)
	Alternative method for Q3 using triangle of forces		
	Attempt at cosine rule from triangle of forces	M1	Must use lengths 4 and $0.3g$ with a suitable angle. Allow g missing.
	$T^2 = 4^2 + (0.3g)^2 - 2 \times 4 \times (0.3g) \times \cos 30$	A1	
	Tension = 2.05	A1	Tension = 2.05314... AWRT 2.05
	Attempt at sin rule	M1	Must have angle 30° and another angle in terms of α with correct numerators, but allow g missing.
	$\frac{\text{Their } T}{\sin 30} = \frac{4}{\sin(180 - \alpha)} \quad \text{or} \quad \frac{\text{Their } T}{\sin 30} = \frac{0.3g}{\sin(\alpha - 30)}$	A1	Correct. Allow $\sin \alpha$ instead of $\sin(180 - \alpha)$.
	$\alpha = 76.9$	A1	$\alpha = 76.9356\dots$ AWRT 76.9

Question	Answer	Marks	Guidance
	Alternative method for Q3 using Lami's theorem		
	Attempt at Lami's theorem	M1	Must have numerators correct and at least one angle correct. Allow g missing.
	$\frac{4}{\sin \alpha} = \frac{0.3g}{\sin(210 - \alpha)} = \frac{T}{\sin(150)}$	A1 A1	A1 for two parts second A1 for all three.
	$\alpha = \tan^{-1}\left(\frac{4\sin 210}{0.3g + 4\cos 210}\right)$	M1	For solving for α using compound angle formula. Must be correct for their angles. Allow g missing.
	$T = \frac{4\sin(150)}{\sin \alpha}$ or $T = \frac{0.3g\sin(150)}{\sin(210 - \alpha)}$	M1	For solving for T using their α . Allow g missing.
	Tension = 2.05 N $\alpha = 76.9$	A1	For both AWRT 2.05, 76.9
		6	
	SC: Tension and the 4N force considered in the wrong directions		
	Attempt to resolve either direction	M1	Correct number of terms. Allow sin/cos mix. Allow sign errors. Allow g missing.
	$T \cos 60^\circ - 4 \sin \alpha^\circ = 0$ And: $T \sin 60^\circ - 4 \cos \alpha^\circ - 0.3g = 0$	A1	For both OE If the two Ts are different, they get SC A0 unless they subsequently state that the two Ts are the same.
	$\left(\frac{T \cos 60^\circ}{4}\right)^2 + \left(\frac{T \sin 60^\circ - 0.3g}{4}\right)^2 = 1 \Rightarrow \frac{1}{4}T^2 + \frac{3}{4}T^2 - 3\sqrt{3}T + 9 = 16$ $\Rightarrow T^2 - 3\sqrt{3}T - 7 = 0 \Rightarrow T = 6.31$ (or -1.11) OR: $4\sqrt{3} \sin \alpha - 4 \cos \alpha = 3 \Rightarrow 8 \sin(\alpha - 30) = 3 \Rightarrow \alpha = \sin^{-1}\frac{3}{8} + 30$	M1	OE Attempt to solve for T or α . No missing/extra terms. Allow g missing. Must get to ' $T =$ ' or ' $\alpha =$ '.
Question	Answer	Marks	Guidance
	$T = 6.31 \text{ N}$ $\alpha = 52.0$	A1	($T = 6.30617\dots$, $\alpha = 52.0243\dots$)
		6	

9. 9709_w22_ms_43 Q: 3

Question	Answer	Marks	Guidance
	$T \cos 25 = 40 + R \cos 50$	M1	Resolving in any direction e.g. horizontal, vertical, along radius or tangent.
	$R \sin 50 = T \sin 25$	M1	Resolving in a second direction.
	Radially: $T \cos 25 = R + 40 \cos 50$ Tangentially: $T \sin 25 = 40 \sin 50$ Parallel to T : $T = R \cos 25 + 40 \cos 25$ Perpendicular to T : $R \sin 25 = 40 \sin 25$ Vertically: $T \cos 25 = 40 + R \cos 50$ Horizontally: $R \sin 50 = T \sin 25$	A1	Two correct equations.
	Solving equation(s) to find either T or R	M1	
	$T = 72.5 \text{ N}$	A1	From 72.504....
	$R = 40 \text{ N}$	A1	
		6	

10. 9709_m21_ms_42 Q: 3

Question	Answer	Marks	Guidance
	For attempting to resolve forces in either direction.	M1	Correct number of relevant terms.
	$T_P \cos 60 = T_R \cos 30$	A1	
	$T_P \sin 60 = T_R \sin 30 + 0.2g$	A1	
	Attempt to solve simultaneously for either tension.	M1	From 2 equations, with correct number of relevant terms.
	$T_P = 3.46 \text{ N}$ and $T_R = 2 \text{ N}$	A1	Both correct. Allow $T_P = 2\sqrt{3} \text{ N}$.
	Alternative method for question 3		
	$\frac{T_P}{\sin 60} = \frac{T_R}{\sin 150} = \frac{0.2g}{\sin 150}$	M1	Attempt one pair of Lami's equations. Correct angles.
	One pair correct	A1	
	Equations all correct	A1	
	Solve for T_P or T_R	M1	From equations of the correct form.
	$T_P = 3.46 \text{ N}$ and $T_R = 2 \text{ N}$	A1	Both correct. Allow $T_P = 2\sqrt{3} \text{ N}$
		5	

11. 9709_s21_ms_41 Q: 6

Question	Answer	Marks	Guidance
(a)	$20 \cos 30 = 25 \cos 60 + 10 \cos \alpha$ [17.32 = 12.5 + 10 cos α , $\rightarrow \cos \alpha = 0.4821$]	M1	For resolving forces horizontally, all relevant terms included
	$\alpha = 61.2$	A1	From $\alpha = 61.18$
	Resultant = $20 \sin 30 + 10 \sin 61.2 - 25 \sin 60$ [= 10 + 8.761 - 21.651]	M1	For resolving forces vertically, all relevant terms included
	Magnitude of resultant force = 2.89 N	A1	A0 for -2.89 N or for $\pm 2.89 \text{ N}$. Allow 2.89 N downwards
		4	
(b)	$X = 25 \cos 60 + 10 \cos 45 - 20 \cos 30$ = 12.5 + 7.07107 - 17.32051 = 2.25056 $Y = 20 \sin 30 + 10 \sin 45 - 25 \sin 60$ = 10 + 7.07107 - 21.65064 = -4.57957	M1	For either horizontal or vertical component, correct number of relevant terms. Allow $\pm X$ and/or $\pm Y$
		A1	For both correct, allow unsimplified
	$R = \sqrt{X^2 + Y^2}$	M1	OE. Using a method to find the resultant force, using expressions for X and Y with at least 5 relevant terms.
	$\alpha = \tan^{-1} \frac{Y}{X}$	M1	OE. A method to find the direction, using expressions for X and Y with at least 5 relevant terms.
	Resultant = 5.10 N, Direction = 63.8° below positive x-axis	A1	For both correct, angle clearly explained. May use a diagram with a correct arrow and arc for angle. Allow angle 296° (measured anticlockwise from +ve x-axis)
		5	