A LEVEL Cambridge Topical Past Papers

MECHANICS

2017 — 2023

PURE MATHEMATICS P4 9709

TOPICAL PAST PAPER WORKSHEETS

2017 - 2023 | Questions + Mark scheme

AVAILABLE PAPERS

P1	P3	P4	P5	P6
490 Questions	432 Questions	299 Questions	287 Questions	257 Questions

www.exam-mate.com

TOPICS	P4
FORCES & IQUILIBRIUM	52
KINEMATICS OF MOTION IN A STRAIGHT LINE	61
NEWTON'S LAWS OF MOTION	77
ENERGY ,WORK & POWER	62
GENERAL MOTION IN STRAIGHT LINE	27
MOMENTUM	20

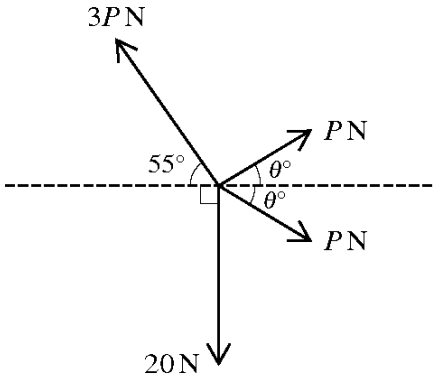
1 - (9709/41_Summer_2017_Q2) - *Forces & Equilibrium*

A particle of mass 0.8 kg is projected with a speed of $12\,\text{m s}^{-1}$ up a line of greatest slope of a rough plane inclined at an angle of $10°$ to the horizontal. The coefficient of friction between the particle and the plane is 0.4.

(i) Find the acceleration of the particle. [4]

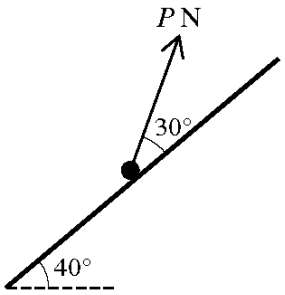
(ii) Find the distance the particle moves up the plane before coming to rest. [2]

2 – (9709/43_Summer_2017_Q2) – *Forces & Equilibrium*



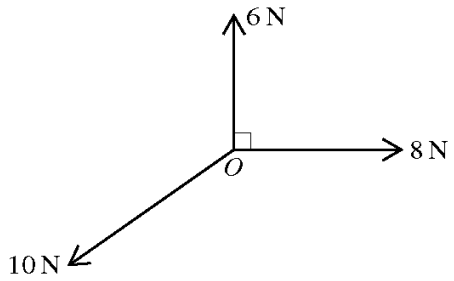
The four coplanar forces shown in the diagram are in equilibrium. Find the values of P and θ. [5]

3 – (9709/42_Summer_2017_Q5) – *Forces & Equilibrium*



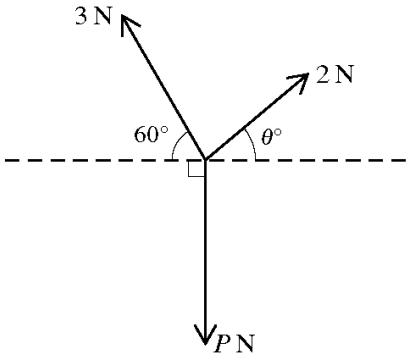
A particle of mass 0.12 kg is placed on a plane which is inclined at an angle of 40° to the horizontal. The particle is kept in equilibrium by a force of magnitude P N acting up the plane at an angle of 30° above a line of greatest slope, as shown in the diagram. The coefficient of friction between the particle and the plane is 0.32. Find the set of possible values of P. [8]

4 – (9709/41_Summer_2018_Q2) – *Forces & Equilibrium*



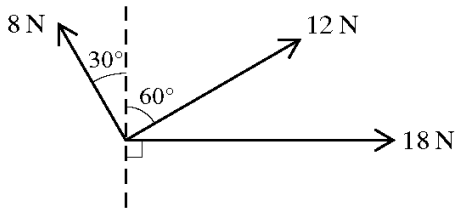
The diagram shows three coplanar forces acting at the point O. The magnitudes of the forces are 6 N, 8 N and 10 N. The angle between the 6 N force and the 8 N force is 90°. The forces are in equilibrium. Find the other angles between the forces. [4]

5 - (9709/42_Summer_2018_Q3) - *Forces & Equilibrium*



The three coplanar forces shown in the diagram have magnitudes 3 N, 2 N and P N. Given that the three forces are in equilibrium, find the values of θ and P. [4]

6 – (9709/43_Summer_2018_Q3) – *Forces & Equilibrium*



Coplanar forces of magnitudes 8 N, 12 N and 18 N act at a point in the directions shown in the diagram. Find the magnitude and direction of the single additional force acting at the same point which will produce equilibrium. [6]

ANSWERS

1 – (9709/41_Summer_2017_Q2) – *Forces & Equilibrium*

(i)	$R = 0.8g \cos 10$ [= 7.88]	**B1**
	$F = 0.4 \times 8 \cos 10$ [= 3.15]	**M1**
	$-8 \sin 10 - 3.2 \cos 10 = 0.8a$	**M1**
	$a = -5.68\ \text{ms}^{-2}$	**A1**
	Total:	**4**
(ii)	$0 = 12^2 - 2 \times 5.68 \times s$	**M1**
	$s = 144/(2 \times 5.68) = 12.7\ \text{m}$	**A1**
	Total:	**2**

2 – (9709/43_Summer_2017_Q2) – *Forces & Equilibrium*

EITHER: $3P \sin 55 + P \sin \theta = 20 + P \sin \theta$ or $3P \sin 55 = 20$	**(M1**
$P = 8.14$	**A1**
$3P \cos 55 = 2P \cos \theta$	**M1**
$\cos \theta = 1.5 \cos 55 \rightarrow \theta = \ldots$	**M1**
$\theta = 30.6$	**A1)**
OR: $\frac{3P}{\sin 90} = \frac{20}{\sin 125}$	**(M1**
$P = 8.14$	**A1**
$\frac{3P}{\sin 90} = \frac{2P \cos \theta}{\sin 145}$	**M1**
$\cos \theta = 1.5 \sin 145 \rightarrow \theta = \ldots$	**M1**
$\theta = 30.6$	**A1)**
Total:	**5**

3 – (9709/42_Summer_2017_Q5) – *Forces & Equilibrium*

	M1
$R + P \sin 30 = 0.12g \cos 40$	**A1**
$F = 0.32R$	**M1**
$[P_{\min} \cos 30 + F = 0.12g \sin 40]$	**M1**
$[P_{\max} \cos 30 - F = 0.12g \sin 40]$	**M1**
$[P \cos 30 = 0.12g \sin 40$ $\pm 0.32 (0.12g \cos 40 - P \sin 30)]$ OR $[P \cos 30 \pm 0.32R = 0.12g \sin 40$ $R + P \sin 30 = 0.12g \cos 40]$ Must reach $P =\ldots$ in either method	**M1**
$P_{\max} = 1.04\, P_{\min} = 0.676$	**A1**
$0.676 \leqslant P \leqslant 1.04$	**A1**
Total:	**8**

4 – (9709/41_Summer_2018_Q2) – *Forces & Equilibrium*

	[10 cos α = 8 or 10 cos β = 6]	**M1**	Introduce α or β, an angle between the 10N force and the vertical or horizontal and attempt to resolve forces
	α = 36.9 or β = 53.1	**A1**	
	Angle between 6N and 10N is 126.9	**B1**	
	Angle between 8N and 10N is 143.1	**B1**	
		4	
	Alternative scheme for Question 2		
	$\frac{10}{\sin 90} = \frac{6}{\sin \gamma} = \frac{8}{\sin \delta}$	**M1**	Attempt to use Lami's theorem γ (8 and 10), δ (6 and 10)
	All correct	**A1**	
	Angle between 8N and 10N is γ =143.1	**B1**	
	Angle between 6N and 10N is δ =126.9	**B1**	

5 – (9709/42_Summer_2018_Q3) – *Forces & Equilibrium*

	[3 cos 60 = 2 cos θ]	M1	Attempt to resolve forces horizontally (2 terms)
	θ = 41.4	A1	
	[P = 3 sin 60 + 2 sin θ]	M1	Attempt to resolve forces vertically (3 terms)
	P = 3.92	A1	
		4	
	First alternative method for Q3		
	$\frac{P}{\sin(120-\theta)}=\frac{2}{\sin 150}=\frac{3}{\sin(90+\theta)}$	M1	Attempt two terms of Lami's equation which can be used to find θ
	θ = 41.4	A1	
		M1	Attempt an equation which can be used to find P
	P = 3.92	A1	
	Second alternative method for Q3		
	[Triangle with sides 2, 3, P and angles opposite of 30, 90 – θ, 60 + θ] $\frac{P}{\sin(60+\theta)}=\frac{2}{\sin 30}=\frac{3}{\sin(90-\theta)}$	M1	Attempt two terms from the triangle of forces which can be used to find θ
	θ = 41.4	A1	
		M1	Attempt an equation which can be used to find P
	P = 3.92	A1	

6 – (9709/43_Summer_2018_Q3) – *Forces & Equilibrium*

		M1	For resolving forces in any one direction
	E.g. $X = 18+12\sin 60°-8\sin 30°$ $14+6\sqrt{3}$	A1	One correct equation or expression
	E.g. $Y = 8\cos 30°+12\cos 60°$ $6+4\sqrt{3}$	A1	Second correct equation or expression (X and Y may denote components of resultant of given 3 forces or may be components of the fourth force that would produce equilibrium)
	$[(14+6\sqrt{3})^2+(6+4\sqrt{3})^2]$ or $[\tan^{-1}(6+4\sqrt{3})/(14+6\sqrt{3})]$	M1	Use of Pythagoras or appropriate trig to find magnitude or angle
	Magnitude is 27.6 (N)	A1	Not for resultant
	Direction is 27.9° below 'negative x-axis'	A1	Not for 27.9° only; direction must be clearly specified
	Total:	6	

7 – (9709/42_Summer_2018_Q5) – *Forces & Equilibrium, Newton's Laws Of Motion*

	$R = 20g\cos 60$ [= 100]	B1	
	$F = \mu \times 20g\cos 60$ [= 100μ]	M1	Use $F = \mu R$
		M1	Resolve along plane in either case
	$(P_{max} =) 20g\sin 60 + F$	A1	One correct equation
	$(P_{min} =) 20g\sin 60 - F$	A1	Second correct equation
	$20g\sin 60 + F = 2(20g\sin 60 - F)$	M1	Use of $P_{max} = 2P_{min}$ to give four term equation in F or μ or P
	$\mu = \frac{\sqrt{3}}{3} = 0.577$	A1	
		7	
	Iternative solution for final 3 marks if P_{min} is taken as acting down the plane		
	$P_{min} = F - 20g\sin 60$	A1	
	$20g\sin 60 + F = 2(F - 20g\sin 60)$	M1	
	$\mu = 3\sqrt{3} = 5.196$	A1	