Cambridge International AS & A Level

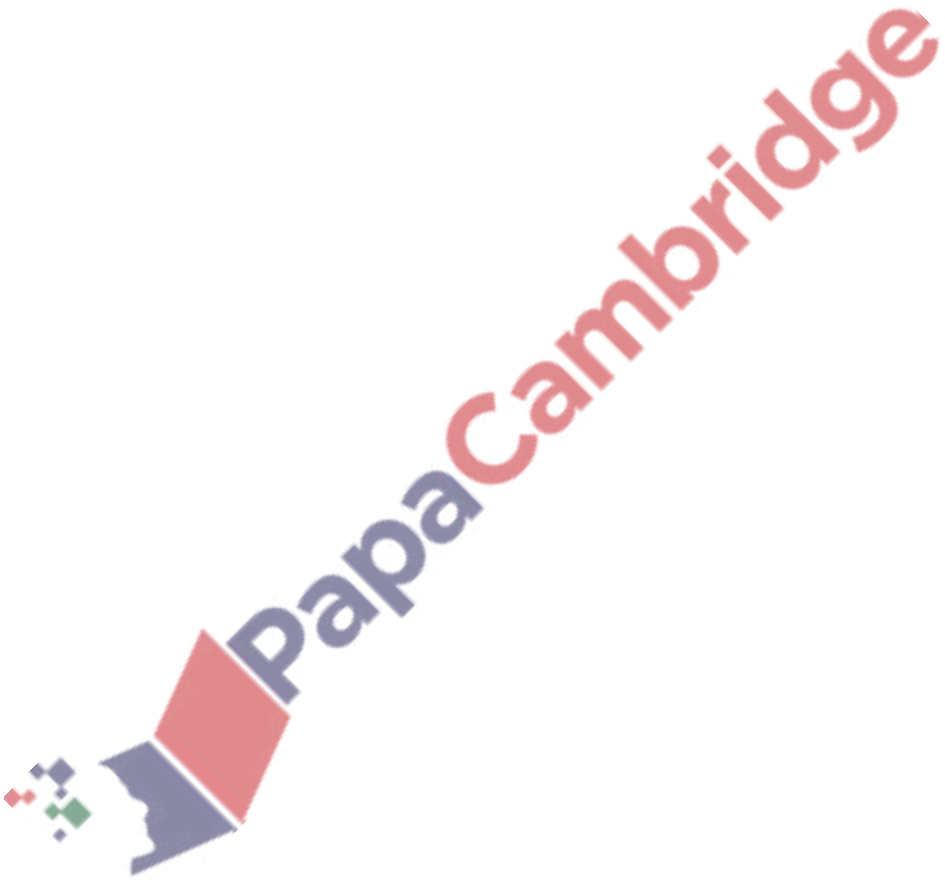
MATHEMATICS (9709) P4

TOPIC WISE QUESTIONS + ANSWERS | COMPLETE SYLLABUS

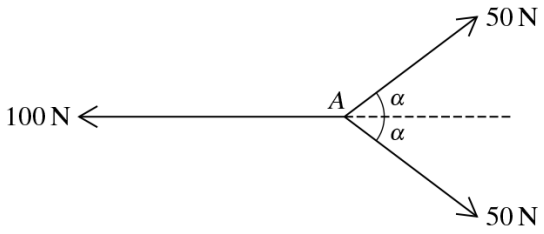
PapaCambridge

Chapter 1

Forces and equilibrium



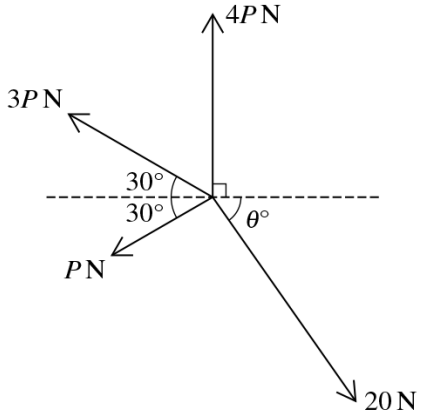
1. 9709_s20_qp_41 Q: 1



Three coplanar forces of magnitudes 100 N, 50 N and 50 N act at a point A, as shown in the diagram. The value of $\cos\alpha$ is $\frac{4}{5}$.

Find the magnitude of the resultant of the three forces and state its direction. [3]

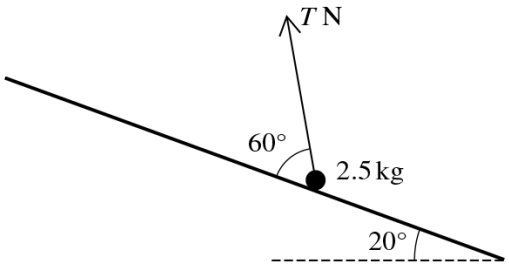
2. 9709_s20_qp_42 Q: 2



Coplanar forces of magnitudes 20 N, P N, $3P$ N and $4P$ N act at a point in the directions shown in the diagram. The system is in equilibrium.

Find P and θ. [6]

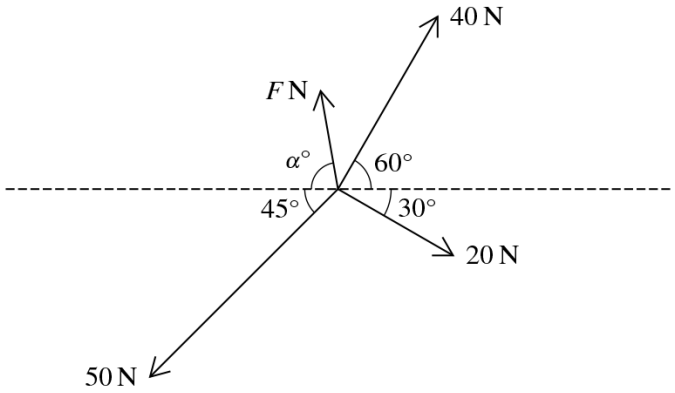
3. 9709_s20_qp_42 Q: 3



A particle of mass 2.5 kg is held in equilibrium on a rough plane inclined at 20° to the horizontal by a force of magnitude T N making an angle of 60° with a line of greatest slope of the plane (see diagram). The coefficient of friction between the particle and the plane is 0.3.

Find the greatest and least possible values of T. [8]

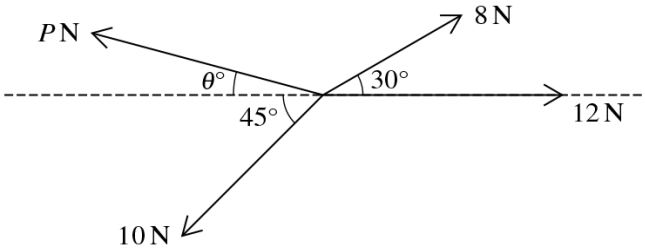
4. 9709_s20_qp_43 Q: 3



Four coplanar forces of magnitudes 40 N, 20 N, 50 N and F N act at a point in the directions shown in the diagram. The four forces are in equilibrium.

Find F and α. [6]

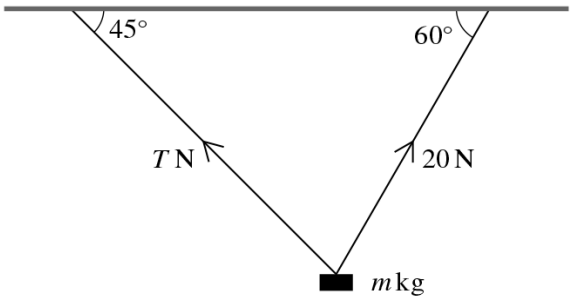
5. 9709_W20_qp_41 Q: 3



Coplanar forces of magnitudes 8 N, 12 N, 10 N and P N act at a point in the directions shown in the diagram. The system is in equilibrium.

Find P and θ. [6]

6. 9709_W20_qp_42 Q: 3



A block of mass m kg is held in equilibrium below a horizontal ceiling by two strings, as shown in the diagram. One of the strings is inclined at 45° to the horizontal and the tension in this string is T N. The other string is inclined at 60° to the horizontal and the tension in this string is 20 N.

Find T and m. [5]

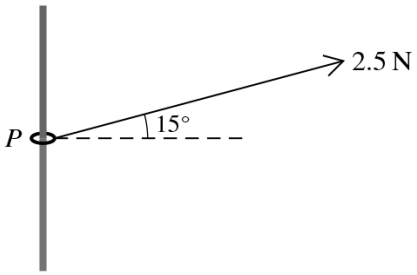
7. 9709_W20_qp_43 Q: 3

A string is attached to a block of mass 4 kg which rests in limiting equilibrium on a rough horizontal table. The string makes an angle of 24° above the horizontal and the tension in the string is 30 N.

(a) Draw a diagram showing all the forces acting on the block. [1]

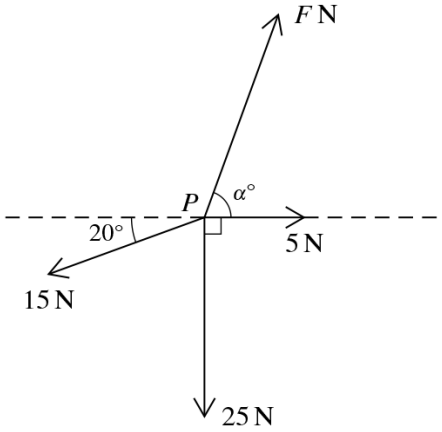
(b) Find the coefficient of friction between the block and the table. [5]

8. 9709_m19_qp_42 Q: 1



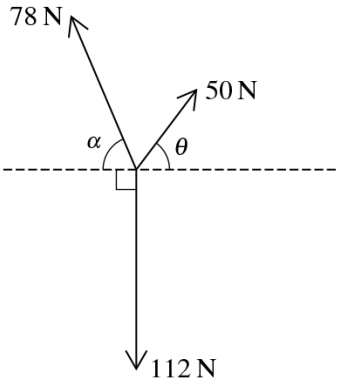
A small ring P of mass 0.03 kg is threaded on a rough vertical rod. A light inextensible string is attached to the ring and is pulled upwards at an angle of 15° to the horizontal. The tension in the string is 2.5 N (see diagram). The ring is in limiting equilibrium and on the point of sliding up the rod. Find the coefficient of friction between the ring and the rod. [4]

9. 9709_m19_qp_42 Q: 3



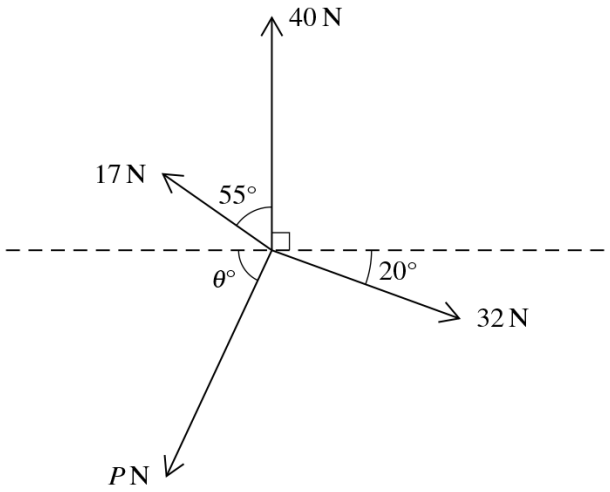
Four coplanar forces of magnitudes F N, 5 N, 25 N and 15 N are acting at a point P in the directions shown in the diagram. Given that the forces are in equilibrium, find the values of F and α. [6]

10. 9709_s19_qp_41 Q: 1



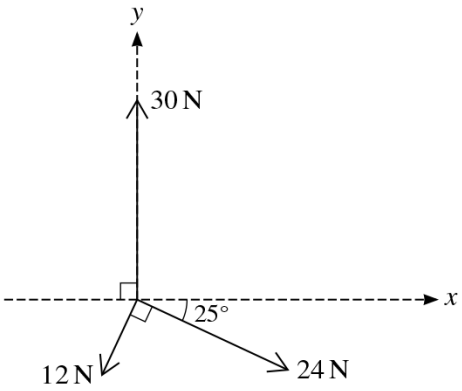
Given that $\tan\alpha = \frac{12}{5}$ and $\tan\theta = \frac{4}{3}$, show that the coplanar forces shown in the diagram are in equilibrium. [3]

11. 9709_s19_qp_42 Q: 1



Coplanar forces of magnitudes 40 N, 32 N, P N and 17 N act at a point in the directions shown in the diagram. The system is in equilibrium. Find the values of P and θ. [6]

12. 9709_s19_qp_43 Q: 2



Coplanar forces of magnitudes 12 N, 24 N and 30 N act at a point in the directions shown in the diagram.

(i) Find the components of the resultant of the three forces in the x-direction and in the y-direction. [4]

Component in x-direction.....

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.....

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Component in y-direction.....

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(ii) Hence find the direction of the resultant. [2]

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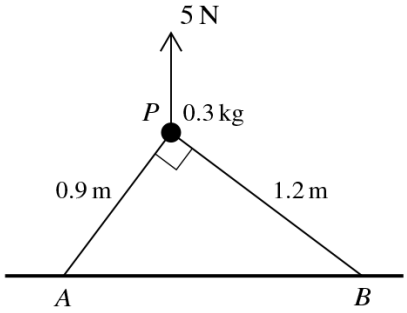
13. 9709_w19_qp_42 Q: 3

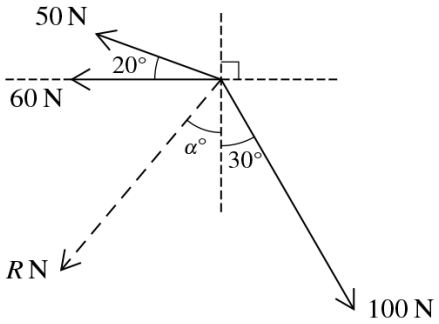


A particle P of mass 0.3 kg is held in equilibrium above a horizontal plane by a force of magnitude 5 N, acting vertically upwards. The particle is attached to two strings PA and PB of lengths 0.9 m and 1.2 m respectively. The points A and B lie on the plane and angle $APB = 90°$ (see diagram). Find the tension in each of the strings. [5]

14. 9709_w19_qp_43 Q: 1

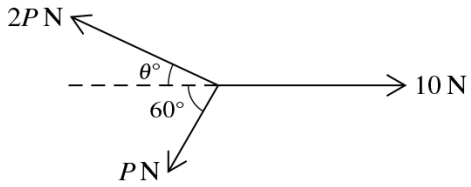
A crate of mass 500 kg is being pulled along rough horizontal ground by a horizontal rope attached to a winch. The winch produces a constant pulling force of 2500 N and the crate is moving at constant speed. Find the coefficient of friction between the crate and the ground. [3]

15. 9709_w19_qp_43 Q: 3



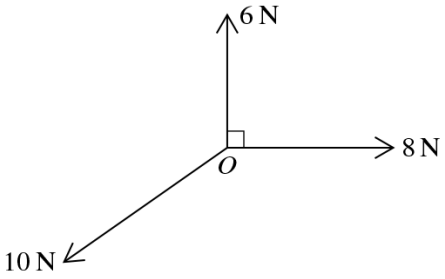
Three coplanar forces of magnitudes 50 N, 60 N and 100 N act at a point. The resultant of the forces has magnitude R N. The directions of these forces are shown in the diagram. Find the values of R and α. [6]

16. 9709_m18_qp_42 Q: 2



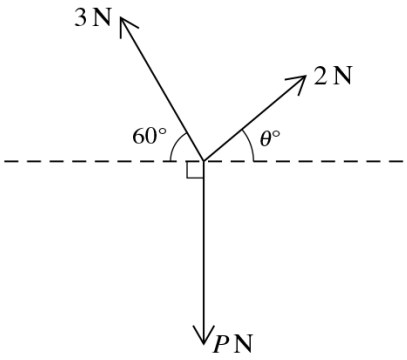
The three coplanar forces shown in the diagram are in equilibrium. Find the values of θ and P. [4]

17. 9709_s18_qp_41 Q: 2



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]

18. 9709_s18_qp_42 Q: 3

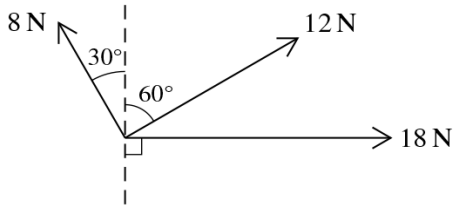


The three coplanar forces shown in the diagram have magnitudes 3 N, 2 N and P N. Given that the three forces are in equilibrium, find the values of θ and P. [4]

19. 9709_s18_qp_42 Q: 5

A particle of mass 20 kg is on a rough plane inclined at an angle of 60° to the horizontal. Equilibrium is maintained by a force of magnitude P N acting on the particle, in a direction parallel to a line of greatest slope of the plane. The greatest possible value of P is twice the least possible value of P. Find the value of the coefficient of friction between the particle and the plane. [7]

20. 9709_s18_qp_43 Q: 3

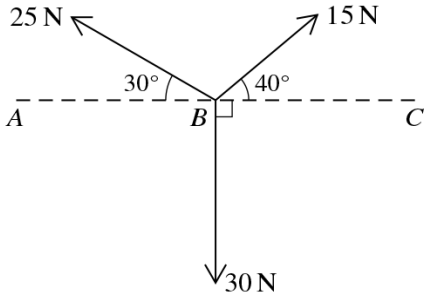


Coplanar forces of magnitudes 8 N, 12 N and 18 N act at a point in the directions shown in the diagram. Find the magnitude and direction of the single additional force acting at the same point which will produce equilibrium. [6]

21. 9709_s18_qp_43 Q: 5

A particle of mass 3 kg is on a rough plane inclined at an angle of 20° to the horizontal. A force of magnitude P N acting parallel to a line of greatest slope of the plane is used to keep the particle in equilibrium. The coefficient of friction between the particle and the plane is 0.35. Show that the least possible value of P is 0.394, correct to 3 significant figures, and find the greatest possible value of P. [6]

22. 9709_w18_qp_41 Q: 5

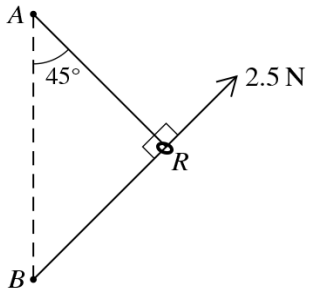


Coplanar forces, of magnitudes 15 N, 25 N and 30 N, act at a point B on the line ABC in the directions shown in the diagram.

(i) Find the magnitude and direction of the resultant force. [6]

(ii) The force of magnitude 15 N is now replaced by a force of magnitude F N acting in the same direction. The new resultant force has zero component in the direction BC. Find the value of F, and find also the magnitude and direction of the new resultant force. [3]

23. 9709_w18_qp_42 Q: 1

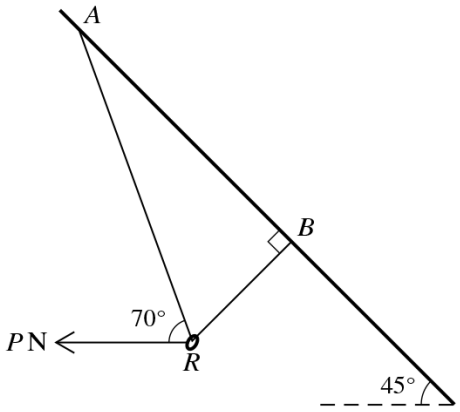


A smooth ring R of mass m kg is threaded on a light inextensible string ARB. The ends of the string are attached to fixed points A and B with A vertically above B. The string is taut and angle $ARB = 90°$. The angle between the part AR of the string and the vertical is 45°. The ring is held in equilibrium in this position by a force of magnitude 2.5 N, acting on the ring in the direction BR (see diagram). Calculate the tension in the string and the mass of the ring. [4]

24. 9709_w18_qp_42 Q: 2

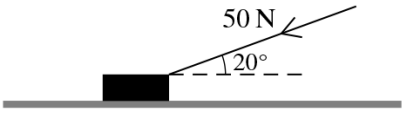
A block of mass 5 kg is being pulled by a rope up a rough plane inclined at 6° to the horizontal. The rope is parallel to a line of greatest slope of the plane and the block is moving at constant speed. The coefficient of friction between the block and the plane is 0.3. Find the tension in the rope. [4]

25. 9709_w18_qp_43 Q: 1



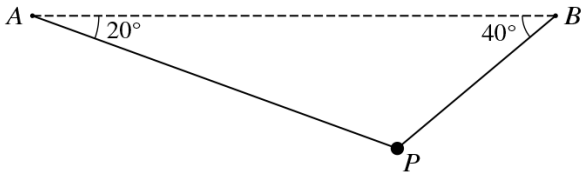
A small smooth ring R of mass 0.2 kg is threaded onto a light inextensible string ARB. The two ends of the string are attached to points A and B on a sloping roof inclined at 45° to the horizontal. A horizontal force of magnitude P N, acting in the plane ARB, is applied to the ring. The section BR of the string is perpendicular to the roof and the section AR of the string is inclined at 70° to the horizontal (see diagram). The system is in equilibrium. Find the tension in the string and the value of P. [4]

26. 9709_w18_qp_43 Q: 2



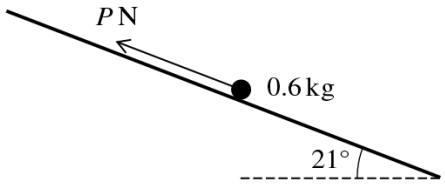
A block is pushed along a horizontal floor by a force of magnitude 50 N which acts at an angle of 20° to the horizontal (see diagram). The coefficient of friction between the block and the floor is 0.3. Given that the speed of the block is constant, find the mass of the block. [5]

27. 9709_m17_qp_42 Q: 2



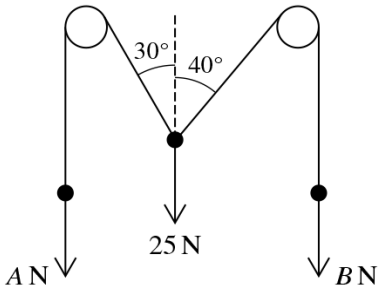
A particle P of mass 1.6 kg is suspended in equilibrium by two light inextensible strings attached to points A and B. The strings make angles of 20° and 40° respectively with the horizontal (see diagram). Find the tensions in the two strings. [6]

28. 9709_m17_qp_42 Q: 3



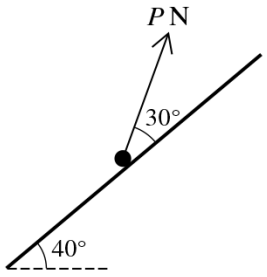
A particle of mass 0.6 kg is placed on a rough plane which is inclined at an angle of 21° to the horizontal. The particle is kept in equilibrium by a force of magnitude P N acting parallel to a line of greatest slope of the plane, as shown in the diagram. The coefficient of friction between the particle and the plane is 0.3. Show that the least possible value of P is 0.470, correct to 3 significant figures, and find the greatest possible value of P. [6]

29. 9709_s17_qp_41 Q: 3



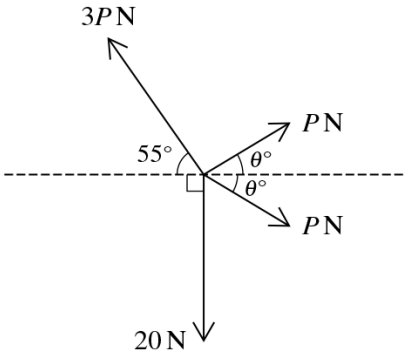
Two light inextensible strings are attached to a particle of weight 25 N. The strings pass over two smooth fixed pulleys and have particles of weights A N and B N hanging vertically at their ends. The sloping parts of the strings make angles of 30° and 40° respectively with the vertical (see diagram). The system is in equilibrium. Find the values of A and B. [6]

30. 9709_s17_qp_42 Q: 5



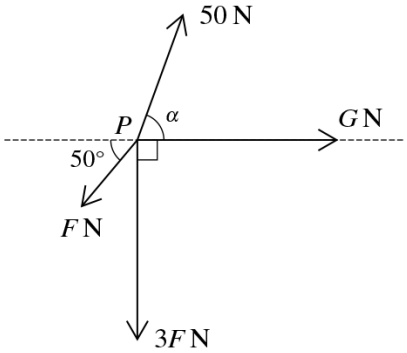
A particle of mass 0.12 kg is placed on a plane which is inclined at an angle of 40° to the horizontal. The particle is kept in equilibrium by a force of magnitude P N acting up the plane at an angle of 30° above a line of greatest slope, as shown in the diagram. The coefficient of friction between the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

31. 9709_s17_qp_43 Q: 2



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

32. 9709_w17_qp_41 Q: 6

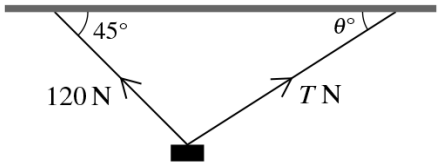


Coplanar forces, of magnitudes F N, $3F$ N, G N and 50 N, act at a point P, as shown in the diagram.

(i) Given that $F = 0$, $G = 75$ and $\alpha = 60°$, find the magnitude and direction of the resultant force. [4]

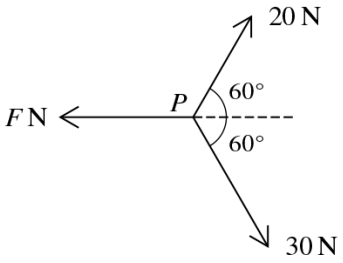
(ii) Given instead that $G = 0$ and the forces are in equilibrium, find the values of F and α. [5]

33. 9709_w17_qp_42 Q: 2



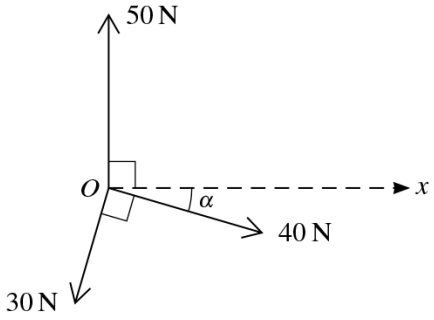
A block of mass 15 kg hangs in equilibrium below a horizontal ceiling attached to two strings as shown in the diagram. One of the strings is inclined at 45° to the horizontal and the tension in this string is 120 N. The other string is inclined at θ° to the horizontal and the tension in this string is T N. Find the values of T and θ. [6]

34. 9709_w17_qp_43 Q: 1



Three coplanar forces of magnitudes F N, 20 N and 30 N act at a point P, as shown in the diagram. The resultant of the three forces acts in a direction perpendicular to the force of magnitude F N. Find the value of F. [3]

35. 9709_m16_qp_42 Q: 3

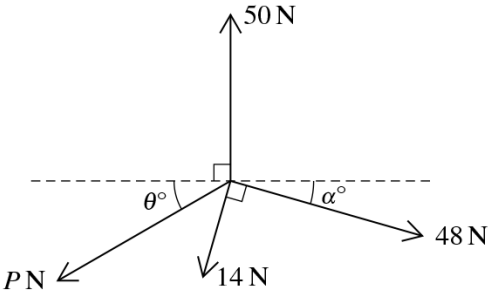


Coplanar forces of magnitudes 50 N, 40 N and 30 N act at a point O in the directions shown in the diagram, where $\tan\alpha = \frac{7}{24}$.

(i) Find the magnitude and direction of the resultant of the three forces. [6]

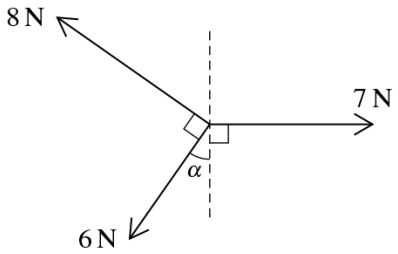
(ii) The force of magnitude 50 N is replaced by a force of magnitude P N acting in the same direction. The resultant of the three forces now acts in the positive x-direction. Find the value of P. [1]

36. 9709_s16_qp_41 Q: 4



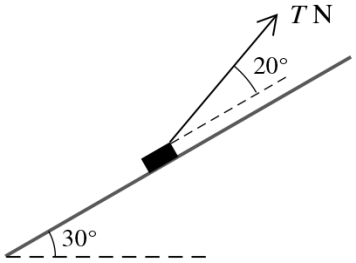
Coplanar forces of magnitudes 50 N, 48 N, 14 N and P N act at a point in the directions shown in the diagram. The system is in equilibrium. Given that $\tan\alpha = \frac{7}{24}$, find the values of P and θ. [6]

37. 9709_s16_qp_42 Q: 1



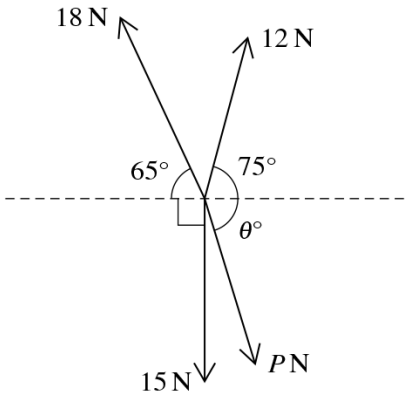
Coplanar forces of magnitudes 7 N, 6 N and 8 N act at a point in the directions shown in the diagram. Given that $\sin\alpha = \frac{3}{5}$, find the magnitude and direction of the resultant of the three forces. [5]

38. 9709_s16_qp_42 Q: 5



A block of mass 2.5 kg is placed on a plane which is inclined at an angle of 30° to the horizontal. The block is kept in equilibrium by a light string making an angle of 20° above a line of greatest slope. The tension in the string is T N, as shown in the diagram. The coefficient of friction between the block and plane is $\frac{1}{4}$. The block is in limiting equilibrium and is about to move up the plane. Find the value of T. [7]

39. 9709_s16_qp_43 Q: 3

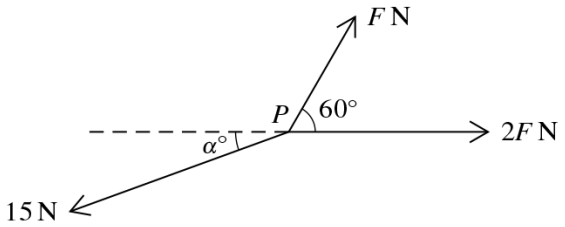


The coplanar forces shown in the diagram are in equilibrium. Find the values of P and θ. [6]

40. 9709_s16_qp_43 Q: 4

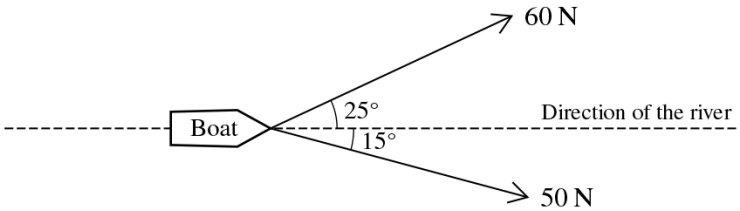
A particle of mass 15 kg is stationary on a rough plane inclined at an angle of 20° to the horizontal. The coefficient of friction between the particle and the plane is 0.2. A force of magnitude X N acting parallel to a line of greatest slope of the plane is used to keep the particle in equilibrium. Show that the least possible value of X is 23.1, correct to 3 significant figures, and find the greatest possible value of X. [7]

41. 9709_w16_qp_41 Q: 4



Three coplanar forces of magnitudes F N, $2F$ N and 15 N act at a point P, as shown in the diagram. Given that the forces are in equilibrium, find the values of F and α. [6]

42. 9709_w16_qp_42 Q: 3



A boat is being pulled along a river by two people. One of the people walks along a path on one side of the river and the other person walks along a path on the opposite side of the river. The first person exerts a horizontal force of 60 N at an angle of 25° to the direction of the river. The second person exerts a horizontal force of 50 N at an angle of 15° to the direction of the river (see diagram).

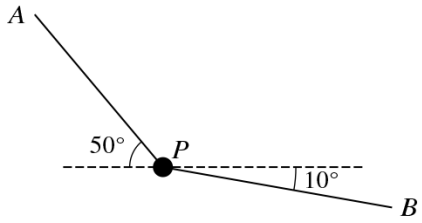
(i) Find the total force exerted by the two people in the direction of the river. [2]

(ii) Find the magnitude and direction of the resultant force exerted by the two people. [4]

43. 9709_w16_qp_42 Q: 5

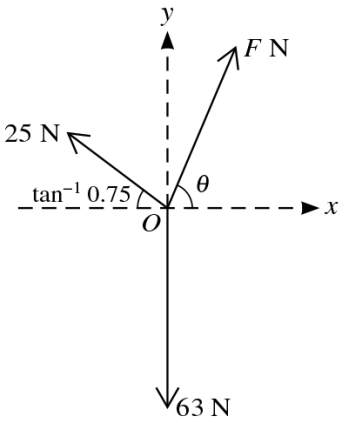
A particle of mass m kg is resting on a rough plane inclined at 30° to the horizontal. A force of magnitude 10 N applied to the particle up a line of greatest slope of the plane is just sufficient to stop the particle sliding down the plane. When a force of 75 N is applied to the particle up a line of greatest slope of the plane, the particle is on the point of sliding up the plane. Find m and the coefficient of friction between the particle and the plane. [6]

44. 9709_w16_qp_43 Q: 2



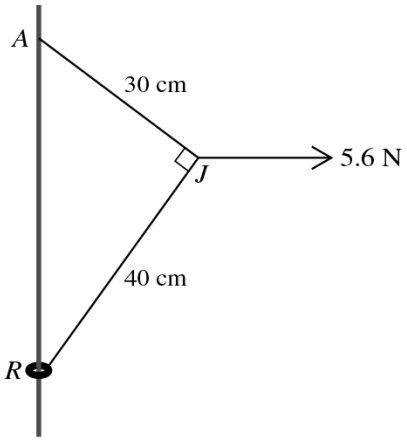
The diagram shows a small object P of mass 20 kg held in equilibrium by light ropes attached to fixed points A and B. The rope PA is inclined at an angle of 50° above the horizontal, the rope PB is inclined at an angle of 10° below the horizontal, and both ropes are in the same vertical plane. Find the tension in the rope PA and the tension in the rope PB. [5]

45. 9709_s15_qp_41 Q: 2



Three horizontal forces of magnitudes F N, 63 N and 25 N act at O, the origin of the x-axis and y-axis. The forces are in equilibrium. The force of magnitude F N makes an angle θ anticlockwise with the positive x-axis. The force of magnitude 63 N acts along the negative y-axis. The force of magnitude 25 N acts at $\tan^{-1} 0.75$ clockwise from the negative x-axis (see diagram). Find the value of F and the value of $\tan\theta$. [5]

46. 9709_s15_qp_42 Q: 7



A small ring R is attached to one end of a light inextensible string of length 70 cm. A fixed rough vertical wire passes through the ring. The other end of the string is attached to a point A on the wire, vertically above R. A horizontal force of magnitude 5.6 N is applied to the point J of the string 30 cm from A and 40 cm from R. The system is in equilibrium with each of the parts AJ and JR of the string taut and angle AJR equal to 90° (see diagram).

(i) Find the tension in the part AJ of the string, and find the tension in the part JR of the string. [5]

The ring R has mass 0.2 kg and is in limiting equilibrium, on the point of moving up the wire.

(ii) Show that the coefficient of friction between R and the wire is 0.341, correct to 3 significant figures. [4]

A particle of mass m kg is attached to R and R is now in limiting equilibrium, on the point of moving down the wire.

(iii) Given that the coefficient of friction is unchanged, find the value of m. [3]

47. 9709_s15_qp_43 Q: 5

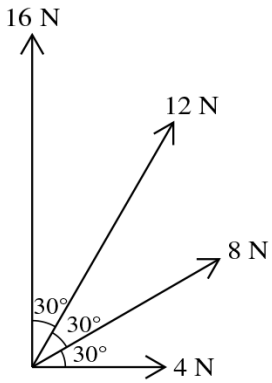


Fig. 1

Four coplanar forces of magnitudes 4 N, 8 N, 12 N and 16 N act at a point. The directions in which the forces act are shown in Fig. 1.

(i) Find the magnitude and direction of the resultant of the four forces. [5]

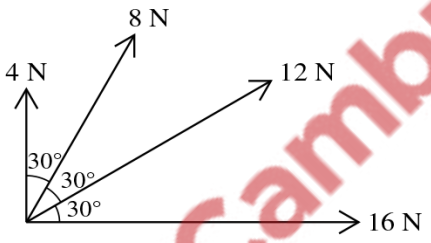
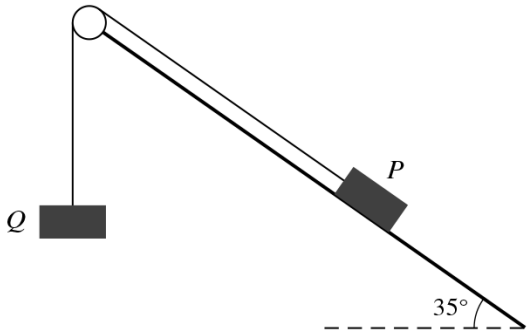


Fig. 2

The forces of magnitudes 4 N and 16 N exchange their directions and the forces of magnitudes 8 N and 12 N also exchange their directions (see Fig. 2).

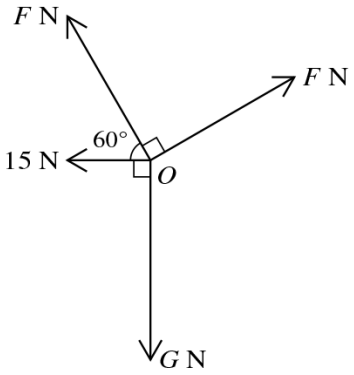
(ii) State the magnitude and direction of the resultant of the four forces in Fig. 2. [2]

48. 9709_w15_qp_41 Q: 4



Blocks P and Q, of mass m kg and 5 kg respectively, are attached to the ends of a light inextensible string. The string passes over a small smooth pulley which is fixed at the top of a rough plane inclined at 35° to the horizontal. Block P is at rest on the plane and block Q hangs vertically below the pulley (see diagram). The coefficient of friction between block P and the plane is 0.2. Find the set of values of m for which the two blocks remain at rest. [6]

49. 9709_w15_qp_42 Q: 1

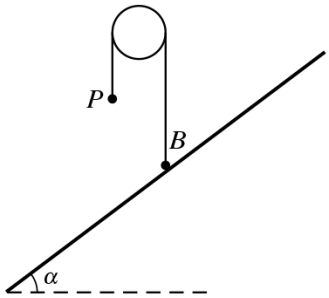


Four horizontal forces act at a point O and are in equilibrium. The magnitudes of the forces are F N, G N, 15 N and F N, and the forces act in directions as shown in the diagram.

(i) Show that $F = 41.0$, correct to 3 significant figures. [3]

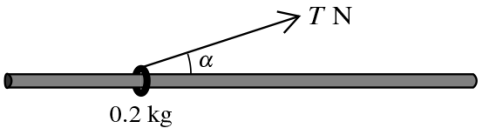
(ii) Find the value of G. [2]

50. 9709_w15_qp_43 Q: 1



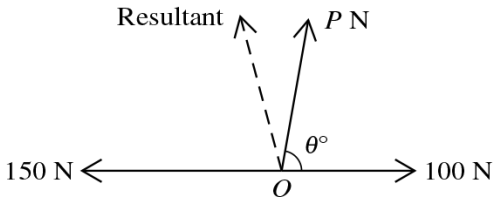
A small ball B of mass 4 kg is attached to one end of a light inextensible string. A particle P of mass 3 kg is attached to the other end of the string. The string passes over a fixed smooth pulley. The system is in equilibrium with the string taut and its straight parts vertical. B is at rest on a rough plane inclined to the horizontal at an angle of α, where $\cos\alpha = 0.8$ (see diagram). State the tension in the string and find the normal component of the contact force exerted on B by the plane. [3]

51. 9709_w15_qp_43 Q: 2



A ring of mass 0.2 kg is threaded on a fixed rough horizontal rod and a light inextensible string is attached to the ring at an angle α above the horizontal, where $\cos\alpha = 0.96$. The ring is in limiting equilibrium with the tension in the string T N (see diagram). Given that the coefficient of friction between the ring and the rod is 0.25, find the value of T. [5]

52. 9709_w15_qp_43 Q: 3



Three horizontal forces of magnitudes 150 N, 100 N and P N have directions as shown in the diagram. The resultant of the three forces is shown by the broken line in the diagram. This resultant has magnitude 120 N and makes an angle 75° with the 150 N force. Find the values of P and θ. [7]