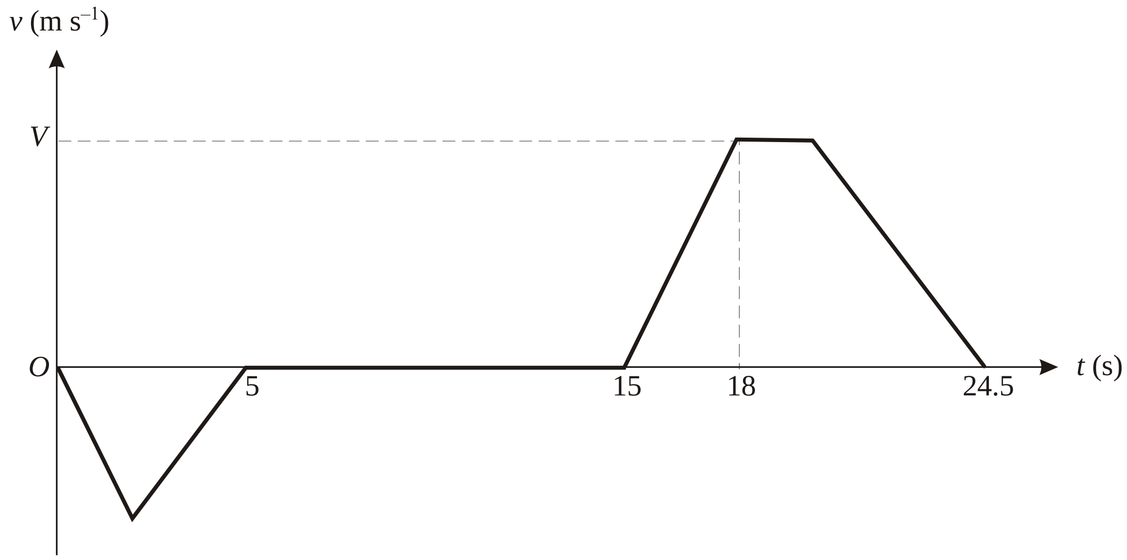
M1 Graphs, SUVAT and Forces practice 1

(Cambridge Questions)

Name...............................

1.



The diagram shows the velocity-time graph for a lift moving between floors in a building. The graph consists of straight line segments. In the first stage the lift travels downwards from the ground floor for 5 s, coming to rest at the basement after travelling 10 m.

(i) Find the greatest speed reached during this stage. **[2]**

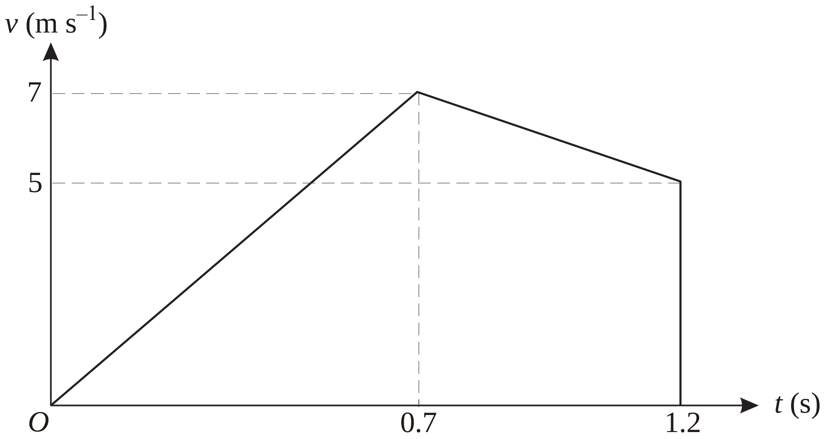
The second stage consists of a 10 s wait at the basement. In the third stage, the lift travels upwards until it comes to rest at a floor 34.5 m above the basement, arriving 24.5 s after the start of the first stage. The lift accelerates at 2 m s^{-2} for the first 3 s of the third stage, reaching a speed of V m s^{-1}. Find

(ii) the value of V, **[2]**

(iii) the time during the third stage for which the lift is moving at constant speed, **[3]**

(iv) the deceleration of the lift in the final part of the third stage. **[2]**

2.



The diagram shows the velocity-time graph for the motion of a small stone which falls vertically from rest at a point A above the surface of liquid in a container. The downward velocity of the stone t s after leaving A is v m s^{-1}. The stone hits the surface of the liquid with velocity 7 m s^{-1} when $t = 0.7$. It reaches the bottom of the container with velocity 5 m s^{-1} when $t = 1.2$.

(i) Find

(a) the height of A above the surface of the liquid,

(b) the depth of liquid in the container.

[3]

(ii) Find the deceleration of the stone while it is moving in the liquid.

[2]

(iii) Given that the resistance to motion of the stone while it is moving in the liquid has magnitude 0.7 N, find the mass of the stone.

[3]

3. A car of mass 1200 kg travels on a horizontal straight road with constant acceleration a m s^{-2}.

(i) Given that the car's speed increases from 10 m s^{-1} to 25 m s^{-1} while travelling a distance of 525 m, find the value of a.

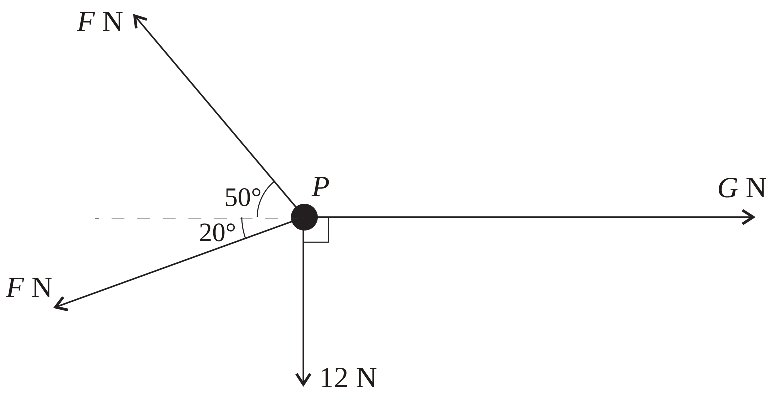
[2]

The car's engine exerts a constant driving force of 900 N. The resistance to motion of the car is constant and equal to R N.

(ii) Find R.

[2]

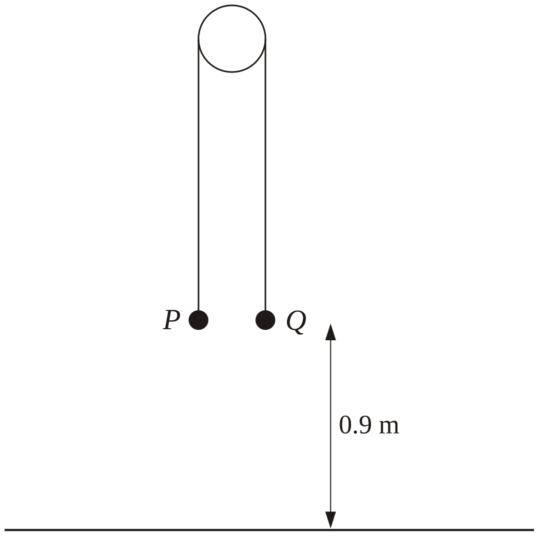
4.



A particle P is in equilibrium on a smooth horizontal table under the action of horizontal forces of magnitudes F N, F N, G N and 12 N acting in the directions shown. Find the values of F and G.

[6]

5.



Particles P and Q, of masses 0.6 kg and 0.2 kg respectively, are attached to the ends of a light inextensible string which passes over a smooth fixed peg. The particles are held at rest with the string taut. Both particles are at a height of 0.9 m above the ground (see diagram). The system is released and each of the particles moves vertically. Find

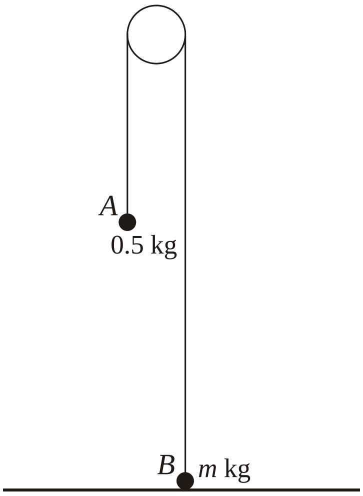
(i) the acceleration of P and the tension in the string before P reaches the ground, **[5]**

(ii) the time taken for P to reach the ground. **[2]**

6. A particle is projected vertically upwards from a point *O* with initial speed 12.5 m s^{-1}. At the same instant another particle is released from rest at a point 10 m vertically above *O*. Find the height above *O* at which the particles meet.

[5]

7.



Particles A and B, of masses 0.5 kg and m kg respectively, are attached to the ends of a light inextensible string which passes over a smooth fixed pulley. Particle B is held at rest on the horizontal floor and particle A hangs in equilibrium (see diagram). B is released and each particle starts to move vertically. A hits the floor 2 s after B is released. The speed of each particle when A hits the floor is 5 ms^{-1}.

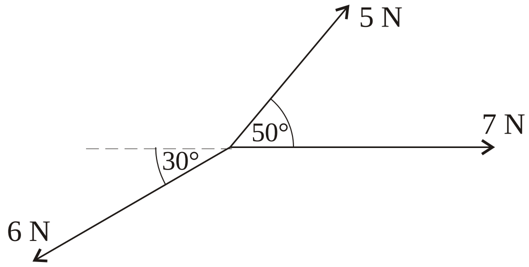
(i) For the motion while A is moving downwards, find

(a) the acceleration of A, **[2]**

(b) the tension in the string. **[3]**

(ii) Find the value of m. **[3]**

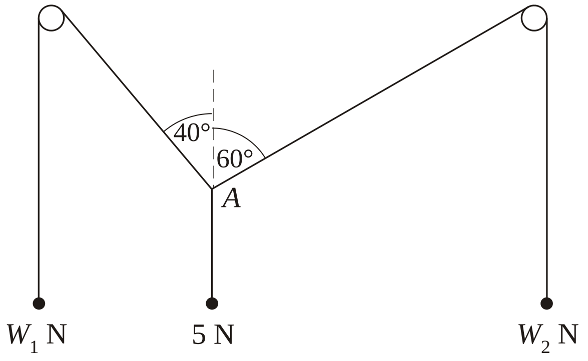
8.



Three coplanar forces act at a point. The magnitudes of the forces are 5 N, 6 N and 7 N, and the directions in which the forces act are shown in the diagram. Find the magnitude and direction of the resultant of the three forces.

[6]

9.



Each of three light strings has a particle attached to one of its ends. The other ends of the strings are tied together at a point A. The strings are in equilibrium with two of them passing over fixed smooth horizontal pegs, and with the particles hanging freely. The weights of the particles, and the angles between the sloping parts of the strings and the vertical, are as shown in the diagram. Find the values of W_1 and W_2.

[6]

10. A car travels in a straight line with constant acceleration a m s^{-2}. It passes the points A, B and C, in this order, with speeds 5 m s^{-1}, 7 m s^{-1} and 8 m s^{-1} respectively. The distances AB and BC are d_1 m and d_2 m respectively.

(i) Write down an equation connecting

(a) d_1 and a,

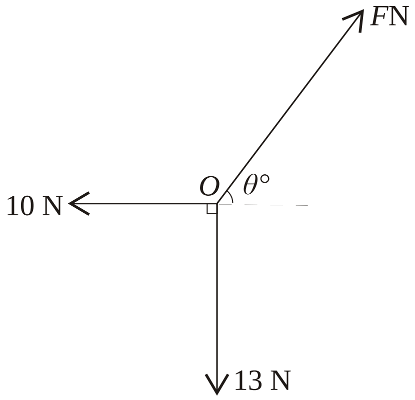
(b) d_2 and a.

[2]

(ii) Hence find d_1 in terms of d_2.

[2]

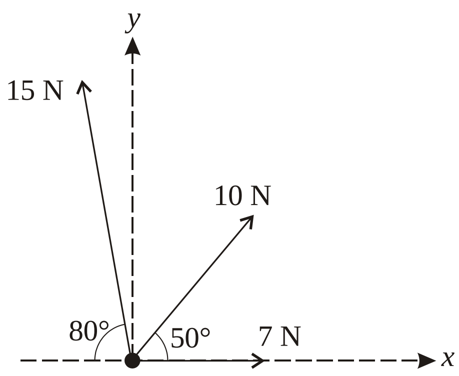
11.



Three horizontal forces of magnitudes F N, 13 N and 10 N act at a fixed point O and are in equilibrium. The directions of the forces are as shown in the diagram. Find, in either order, the value of θ and the value of F.

[5]

12.



Forces of magnitudes 7 N, 10 N and 15 N act on a particle in the directions shown in the diagram.

(i) Find the component of the resultant of the three forces

(a) in the *x*-direction,

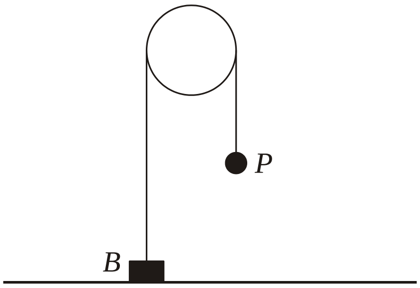
(b) in the *y*-direction.

[3]

(ii) Hence find the direction of the resultant.

[2]

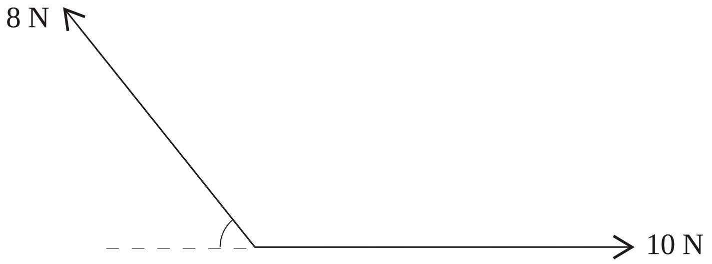
13.



A block B of mass 5 kg is attached to one end of a light inextensible string. A particle P of mass 4 kg is attached to other end of the string. The string passes over a smooth pulley. The system is in equilibrium with the string taut and its straight parts vertical. B is at rest on the ground (see diagram). State the tension in the string and find the force exerted on B by the ground.

[3]

14.



Forces of magnitudes 10 N and 8 N act in directions as shown in the diagram.

(i) Write down in terms of θ the component of the resultant of the two forces

(a) parallel to the force of magnitude 10 N,

[1]

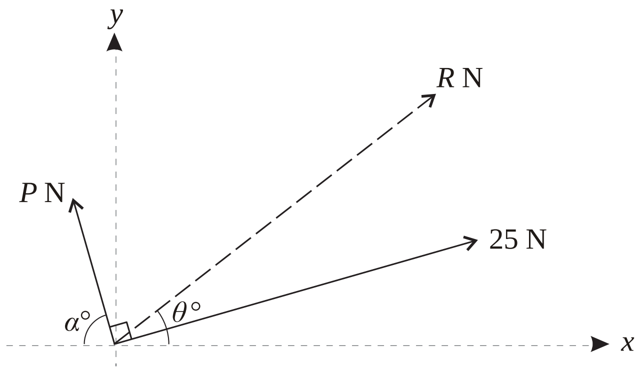
(b) perpendicular to the force of magnitude 10 N.

[1]

(ii) The resultant of the two forces has magnitude 8 N. Show that $\cos\theta = \frac{5}{8}$.

[3]

15.



Forces of magnitudes *PN* and 25 N act at right angles to each other. The resultant of the two forces has magnitude *RN* and makes an angle of $\theta°$ with the x-axis (see diagram). The force of magnitude *P*N has components –2.8 N and 9.6 N in the x-direction and the y-direction respectively, and makes an angle of α° with the negative x-axis.

(i) Find the values of P and R.

[3]

(ii) Find the value of α, and hence find the components of the force of magnitude 25 N in

(a) the x-direction,

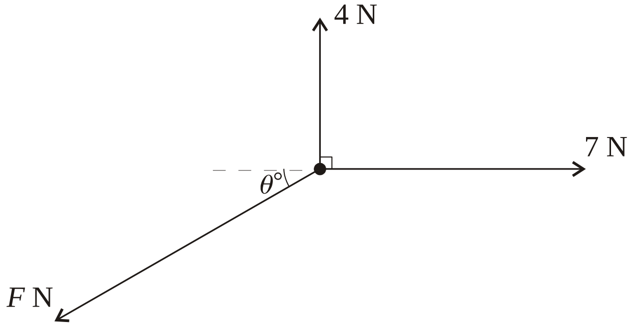
(b) the y-direction.

[4]

(iii) Find the value of θ.

[3]

16.

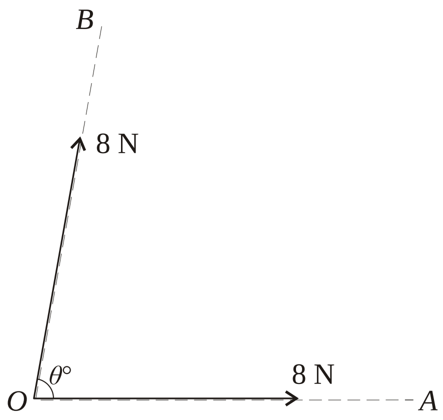


A particle is in equilibrium on a smooth horizontal table when acted on by the three horizontal forces shown in the diagram.

(i) Find the values of F and θ. **[4]**

(ii) The force of magnitude 7 N is now removed. State the magnitude and direction of the resultant of the remaining two forces. **[2]**

17.



Two forces, each of magnitude 8 N, act at a point in the directions *OA* and *OB*. The angle between the forces is $\theta°$ (see diagram). The resultant of the two forces has component 9 N in the direction *OA*. Find

(i) the value of θ,

[2]

(ii) the magnitude of the resultant of the two forces.

[3]

1. (i) $\frac{1}{2}\,5\,v_{max} = \pm 10$ M1

For using the idea that the area of the relevant triangle represents distance

Greatest speed is 4 m s^{-1} A12

(ii) $V/3 = 2$ or $V = 0 + 2 \times 3$ M1

For using the idea that the gradient represents acceleration or $v = 0 + at$

$V = 6$ A12

(iii) For an attempt to find the area of the trapezium in terms of T (or of t) and equate with 34.5 M1

$\frac{1}{2}\,(T + 9.5)6 = 34.5$ or

$\frac{1}{2}(t - 18 + 9.5)6 = 34.5$ A1 ft

Any correct form of equation in T (or t)

Time is 2 s A13

(iv) $d = \dfrac{6}{24.5 - (18 + 2)}$ M1

For using the idea that minus the gradient represents deceleration

Deceleration is 4/3 m s^{-2} A1ft2

[9]

2. (i) For using the area property for displacements or for using $s = (u + v)t/2$ (for (a) or (b)) M1

(a) Height is 2.45 m A1

(b) Depth is 3 m A13

(ii) M1

For using the idea that gradient represents acceleration or for using $v = u + at$

Deceleration is 4 m s^{-2} A12

(iii) M1

For using Newton's second law (3 terms needed)

0.7 – mg = 4m A1ft

Mass is 0.05 kg A13

[8]

3. (i) $25^2 = 10^2 + 1050a$ M1

For using $v^2 = u^2 + 2as$

$a = 0.5$ A12

(ii) 900 – R = 1200 × 0.5 M1

For using Newton's second law

$R = 300$ A1 ft2

Ft value of 900 – 1200a

[4]

4. For resolving forces in the "j" direction M1

$F\sin50° = F\sin20° + 12$ A1

$F = 28.3$ A1

M1

For resolving forces in the "i" direction

$G = F\cos50° + F\cos20°$ A1

$G = 44.8$ A1 ft

Ft value of 1.5825F

[6]

5. (i) For applying Newton's second law to P or to Q (3 terms) — M1

$0.6\,g - T = 0.6a$ — A1

$T - 0.2\,g = 0.2a$ — A1

Allow B1 for $0.6\,g - 0.2\,g = (0.6 + 0.2)a$ as an alternative for either of the above A marks

Acceleration is 5 m s^{-2} — B1

Tension is 3 N — A1 5

(ii) $[0.9 = \tfrac{1}{2}\,5t^2]$ — M1

For using $s = ut + \tfrac{1}{2}at^2$

Time taken is 0.6 s — A1ft 2

ft $\sqrt{1.8/a}$

[7]

6. For applying $s = ut + \tfrac{1}{2}at^2$ or $(u + at)^2 = u^2 + 2as$ with $a = \pm g$ (either particle) — M1

$s_1 = 12.5t - \tfrac{1}{2}gt^2$, $s_2 = \pm\tfrac{1}{2}gt^2$ or — A1

$(12.5 - gt)^2 = 12.5^2 - 2gs_1$ and

$(gt)^2 = 2gs_2$ — A1

$[12.5t - \tfrac{1}{2}gt^2 + \tfrac{1}{2}gt^2 = 10]$ — M1

For using $s_1 + s_2 = 10$

$t = 0.8$s or

$2s_1 = 25\sqrt{2 - 0.2s_1} - (20 - 2s_1$

(or better) — A1

Height is 6.8 m — A1ft

ft for $12.5t - 5t^2$ or $10 - 5t^2$ with candidate's t (requires both M marks)

[5]

7. (i) (a) [5 = 0 + 2a] M1
For using v = u + at with u = 0

Acceleration is 2.5 m s^{-2} A1 2

(b) M1
For applying Newton's second law to A (3 terms): (can be scored in (ii) by applying Newton's second law to B instead)

0.5g – T = 0.5 × 2.5 A1ft

Tension is 3.75 N A1 3

(ii) T – mg = 2.5 m B1ft
ft from T – 0.5g = 0.5 × 2.5 in (i) (b) to allow mg – T = 2.5 m or mg – 0.5g = 0.5 × 2.5 + 2.5 m

[(10 + 2.5)m = 3.75] M1
For solving 3 term equation for m

m = 0.3 A1 3

[8]

8. For finding component X (3 terms) or component Y (2 terms) M1

$X = 7 + 5\cos 50° - 6\cos 30°$ A1

$Y = 5\sin 50° - 6\sin 30°$ A1ft
ft for sin/cos instead of cos/sin and/or 70° (100 – 30) instead of 60° (90 – 30)

SR (max 1/3) for candidates who use Σ **F** + **R** = 0 or Σ **F** = 0 (instead of Σ **F** = **R**).
X = +5.02 or –5.02 and
Y = +0.83 or –0.83

$R^2 = 5.01..^2 + 0.83..^2$ M1
For using $R^2 = X^2 + Y^2$

$\tan\theta = 0.8302/5.0178$ M1
For using $\tan\theta = \dfrac{Y}{X}$

Magnitude is 5.09 N and direction is 9.4° anti-clockwise from force of magnitude 7 N A1

OR:

For finding the resultant $\mathbf{R_1}$ (in magnitude and direction) of any two of the forces. M1

10.9 N and 20.6° anticlockwise from x-axis A1
or 3.50 N and 59.0° clockwise from x-axis
or 2.15 N and 157.3° anticlockwise from x-axis

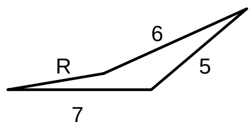
For finding the magnitude of the resultant of $\mathbf{R_1}$ and the third force. M1

5.09 N A1

For finding the direction of the resultant of $\mathbf{R_1}$ and the third force. M1

9.4° anticlockwise from the x-axis A1

OR:



For correct drawing to scale M2

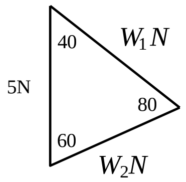
R = 5.09 (**A2**) (or some value such that $4.9 \le R \le 5.3$ (**A1**)) A2 (or A1)

9.4° (**A2**) (or some value such that $9° \le \theta \le 9.8°$ (**A1**)) A2 (or A1)

anticlockwise from the x-axis

[6]

9. Either:



For correct triangle of forces or for resolving forces at the knot either horizontally or vertically — M1

For correct angles and sides marked on the triangle of forces (or later correctly used) or for two correct equations in W_1 and W_2 — A1

$$\frac{W_1}{\sin 60°} = \frac{5}{\sin 80°}$$ M1

For using the sine rule in the triangle of forces to obtain an equation in W_1 or W_2 only, or for eliminating W_2 (or W_1) from simultaneous equations

$W_1 = 4.40$ — A1

$$\frac{W_2}{\sin 40°} = \frac{5}{\sin 80°}$$ M1

For using the sine rule in the triangle of forces again to obtain an equation in W_2 or W_1 only, or for back substitution to obtain an equation in W_2 (or W_1) only

$W_2 = 3.26$ — A16

OR:

$W_1\sin 40° = W_2\sin 60°$ — M1

For correct triangle of forces or for resolving forces at the knot either horizontally or vertically

$W_1\cos 40° + W_2\cos 60° = 5$ — A1

For correct angles and sides marked on the triangle of forces (or later correctly used) or for two correct equations in W_1 and W_2

$W_1\cos 40° + W_1\dfrac{\sin 40°}{\sin 60°}\cos 60° = 5$ — M1

For using the sine rule in the triangle of forces to obtain an equation in W_1 or W_2 only, or for eliminating W_2 (or W_1) from simultaneous equations

$W_1 = 4.40$ A1

$W_2 = 4.40 \frac{\sin 40°}{\sin 60°}$ M1

For using the sine rule in the triangle of forces again to obtain an equation in W_2 or W_1 only, or for back substitution to obtain an equation in W_2 (or W_1) only

$W_2 = 3.26$ A1 6

[6]

10. (i) M1

For using $v^2 = u^2 + 2as$

(a) $7^2 - 5^2 = 2ad_1$, A1 2

(b) $8^2 - 7^2 = 2ad_2$

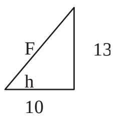
(ii) $\frac{24}{15} = \frac{d_1}{d_2}$ M1

For eliminating a

$d_1 = 1.6d_2$ A1 2

[4]

11.



M1

For resolving forces in **i** and **j** directions
or sketching a triangle of forces (with 10, 13 and F shown)

[Fcos θ° = 10, Fsin θ° = 13;
[tanθ° = 13/10, $\sqrt{269}\sin\theta° = 13$] M1
For an equation in θ only

$\theta = 52.4$ A1

[$F^2 = 10^2 + 13^2$, Fcos52.4° = 10] M1
For an equation in F only

F = 16.4 A1 5

Alternative scheme for candidates who use scale drawing:

For scale drawing of correct triangle	M1
For measuring θ and finding a value in the range [51, 54]	M1
$\theta = 52.4$	A1
For measuring F and finding a value in the range [15.5, 17.5]	M1
F = 16.4	A15
	[10]

12. (i) [$X = 7 + 10\cos 50^\circ - 15\cos 80^\circ$, $Y = 10\sin 50^\circ + 15\sin 80^\circ$] M1
For obtaining an expression for X or Y

(a) x-component is 10.8 N A1

(b) y-component is 22.4 N A13

(ii) [$\theta = \tan^{-1}(22.4/10.8)$] M1
For using $\theta = \tan^{-1}(Y/X)$

Direction 64.2º anticlockwise from x-axis A12
Accept 64.3º

[5]

13. Tension is 40 N B1

[R + T = W] M1
For resolving forces on B vertically

Force exerted is 10 N A1

[3]

14. (i) (a) $10 - 8\cos\theta$ B1

(b) $8\sin\theta$ B12

(ii) M1
For using $X^2 + Y^2 = R^2$ or for using the cosine rule in the relevant triangle

$(10 - 8\cos\theta)^2 + (8\sin\theta)^2 = 8^2$ or
$10^2 + 8^2 - 2 \times 10 \times 8\cos\theta = 8^2$ A1ft

$\cos\theta = 5/8$ A13
AG

First alternative for (ii)

		[cosφ = (10 – 8cos θ)/8 and sinφ = 8sin θ /8] For using cosφ = X/R and sinφ = Y/R	M1
		8 cosφ = (10 – 8cos θ) and φ = θ	A1ft
		cos θ = 5/8 AG	A1
		Second alternative for (ii) [5, $\sqrt{39}$, 64] For assuming cos θ = 5/8 and hence finding exact values of sin θ, X, Y and $X^2 + Y^2$	M1
		R = 8	A1
		→ assumption correct	A1
		SR for (ii) (max 2/3)	
		For assuming cos θ = 5/8 and hence finding θ = 51.3º and the values of X, Y and $X^2 + Y^2$	M1
		R = 8 or 8.0 or 8.00 or 7.997.. → assumption correct	A1
			[5]
15.	(i)	For using $\lvert X\rvert = \sqrt{X_1^{\,2} + X_2^{\,2}}$ for P or R	M1
		P = 10 From $P^2 = (–2.8)^2 + 9.6^2$	A1
		R = 26.9 From $R^2 = 10^2 + 25^2$ or $R^2 = 21.2^2 + 16.6^2$	A1ft3
	(ii)	For using tan α = 9.6/(± 2.8) or equivalent; may be scored in (i)	M1
		α = 73.7 From c.w.o.; may be scored in (i)	A1
		(a) 24N ft 25cos(90 – α)º for α > 0	A1ft
		(b) 7N ft 25sin(90 – α)º for α > 0	A1ft4
	(iii)	For using cos θ = X/R, sin θ = Y/R or tan θ = Y/X, finding X or Yor X and Y as necessary	M1

cos θ = (24 – 2.8)26.9 … or
sin θ = (7 + 9.6)/26.9 … or
tan θ = (7 + 9.6)/(24 – 2.8) A1ft

Alternative for the above 2 marks: For using
$\theta = \tan^{-1}(Y/X) + \tan^{-1}(P/25)$ M1
$\theta = \tan^{-1}(7/24) + \tan^{-1}(10/25)$ A1ft

θ = 38.1 A1 3

[10]

16. (i) [7 = Fcos θ and 4 = Fsin θ ➔
$F^2 = 7^2 + 4^2$ (or tan θ = 4/7)] M1
For stating $F^2 = 7^2 + 4^2$ directly or for resolving in the **i** and **j** directions and eliminating θ or F

F = 8.06 A1
Allow 8.07 from 4 ÷sin 29. 7°

[7 = 8.06cos θ or 4 = 8.06sin θ]
(or 7 = Fcos29.7° or 4 = Fsin29.7°) M1
For stating tanθ = 4/7 directly or for substituting for F or for θ into 7 = Fcos θ or 4 = Fsin θ

θ = 29.7 A1 4
Allow 29.8 from $\sin^{-1}(4 \div 8.06)$

SR for candidates who mix sine and cosine (max 3/4)
Fsin θ = 7, Fcos θ = 4 ➔ $F^2 = 7^2 + 4^2$ M1
For tan θ = 7/4 M1
For F = 7 and θ = 60.3° A1

(ii) Magnitude 7 N B1

Direction opposite to that of the force of magnitude 7 N B1 2
Any equivalent form

[6]

17. (i) [8 + 8cosθ = 9] M1
For an equation in θ using component 9 N

θ = 82.8 A1 2

(ii)	For showing θ or $(180° – \theta)$ or $\theta/2$, in a triangle representing the two forces and the resultant, or for using $Y = 8\sin\theta$ in $R^2 = X^2 + Y^2$ This mark may be implied by a correct equation for $R(\theta)$ in the subsequent working	B1
	$[R^2 = 8^2 + 8^2 – 2 \times 8 \times 8\cos(180 – \theta)$, $R^2 = 8^2 + 8^2 + 2 \times 8 \times 8\cos\theta$, $\cos(\theta/2) = (R/2) \div 8$, $R\cos(\theta/2) = 9$, $R\sin(\theta/2) = 8\sin\theta$, $R^2 = 9^2 + (8\sin\theta)^2$, $R^2 = (8 + 8\cos\theta)^2 + (8\sin\theta)^2]$ For an equation in R or R^2	M1
	Magnitude is 12 N	A13

[5]