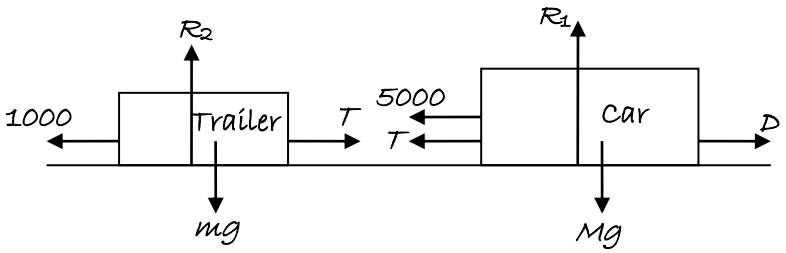
Section 1: Force diagrams and equilibrium

Solutions to Exercise level 2

1. (i) D is the driving force of the car engine.
T is the tension in the towbar.



(ii) Since the car is moving at constant speed, the trailer is in equilibrium
so $T = 1000$ N

(iii) The car is in equilibrium
so $D = 5000 + T$
$= 5000 + 1000$
$= 6000$ N

2. $p(4\underline{i} + 3\underline{j}) + q(12\underline{i} + 5\underline{j}) = 68\underline{i} + 33\underline{j}$

Comparing $\underline{i}$ components: $4p + 12q = 68 \Rightarrow p + 3q = 17 \Rightarrow p = 17 - 3q$
Comparing $\underline{j}$ components: $3p + 5q = 33$
Substituting: $3(17 - 3q) + 5q = 33$
$51 - 9q + 5q = 33$
$4q = 18$
$q = 4.5$
$p = 17 - 3 \times 4.5 = 3.5$

Ann pushes with a force of $3.5(4\underline{i} + 3\underline{j}) = 14\underline{i} + 10.5\underline{j}$
Magnitude of Ann's force $= \sqrt{14^2 + 10.5^2} = 17.5$ N

Beryl pushes with a force of $4.5(12\underline{i} + 5\underline{j}) = 54\underline{i} + 22.5\underline{j}$.
Magnitude of Beryl's force $= \sqrt{54^2 + 22.5^2} = 58.5$ N

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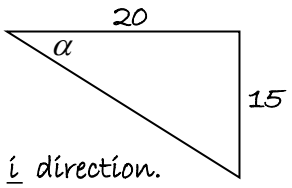
3. (i) Magnitude of force $= \sqrt{20^2 + 15^2} = 25$ N

$\tan\alpha = \frac{15}{20}$

$\alpha = 36.9°$



The force makes an angle of 36.9° below the $\underline{i}$ direction.

(ii) If the particle is in equilibrium, total force is zero.

$(20\underline{i} - 15\underline{j}) + (5\underline{i} - 40\underline{j}) + \underline{F} = 0$

$\underline{F} = -25\underline{i} + 55\underline{j}$