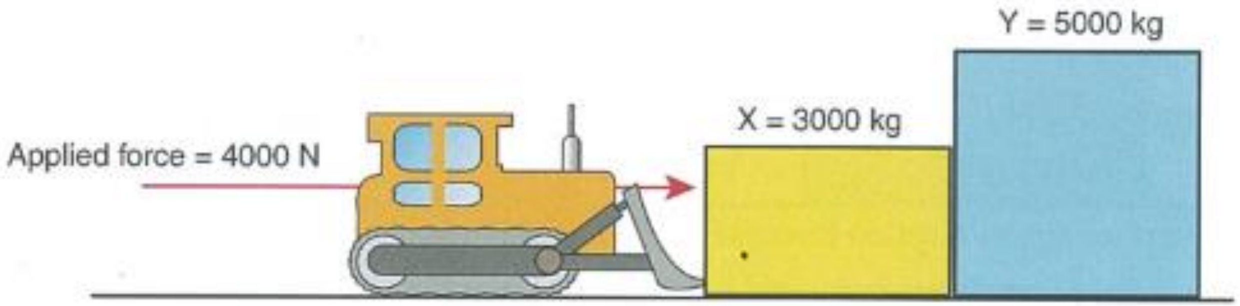
Y11 Physics

End of Year Extras Amazon

Q and A

Q1

Consider a bulldozer pushing with a force of 6000 N on object X which has a mass of 3000 kg. Object X is in contact with object Y, mass 5000 kg, and pushes it along in front of itself. There is a frictional force of 0.25 N kg^{-1} acting on the system as it moves across the surface. The diagram summarises the situation.



Find the acceleration of each mass, the net force on each mass and the force X puts on Y and the force Y puts on X.

Q1 continued

The net force on the system is 4000 N to the right. This is applied to X by the bulldozer. In turn, X pushes on Y. (The bulldozer treads also push on the ground and it is the reaction force of the ground on the treads that moves the bulldozer forwards.)

- Treating the block *system* as a whole, we use Newton's second law to find its acceleration.

  $F = ma$

  $4000 = 8000a$

  So $a = 0.5\ \text{m s}^{-2}$

- Obviously, if the acceleration of X and Y is 0.5 m s^{-2}, the net force acting on them is as follows.

  $F_X = m_X a$ and $F_Y = m_Y a$

  $= 3000 \times 0.5$ $= 5000 \times 0.5$

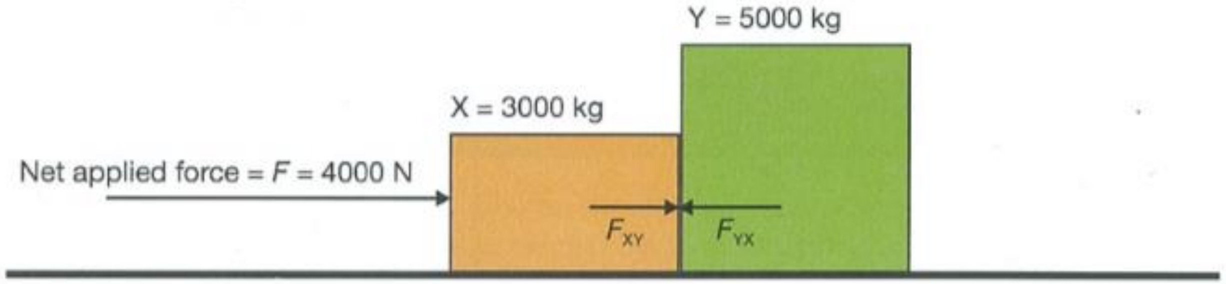
  $= 1500$ N $= 2500$ N

- The 2500 N force on Y is applied by X, so the force of X on Y is 2500 N to the right.
- The bulldozer applies a force on X of 4000 N (right). The net force on X is only 1500 N to the right. So there must be another force of 2500 N acting on X (left). This is the reaction Y applies to X.
- So, the action-reaction force pair on X and Y at their point of contact is 2500 N.

Q1 continued

This situation can also be analysed by writing force equations for each mass.

- To do this we label all the forces acting in the system. We ignore weight force and the reaction to the weight force as motion is horizontal. The diagram shows the forces.



If we let F_{XY} (the force of X pushing on Y) and F_{YX} (the force of Y pushing back on X) be action-reaction force pairs acting on X and Y at the interface where they are in contact, then the equations of motion for these masses are as follows.

For X: net force = $m_X a = F - F_{YX}$

For Y: net force = $m_Y a = F_{XY}$

Substituting the appropriate values:

For X: net force = $3000a = 4000 - F_{YX}$

For Y: net force = $5000a = F_{XY}$

$8000a = 4000$

So $a = 0.5$ m s²

And, solving, the interface action/reaction forces, $F_{XY} = F_{YX} = 2500$ N

Using Newton's second law, the net forces on X and Y are as follows.

Net force on X = $m_X a$

= 3000×0.5

So F_X = 1500 N right

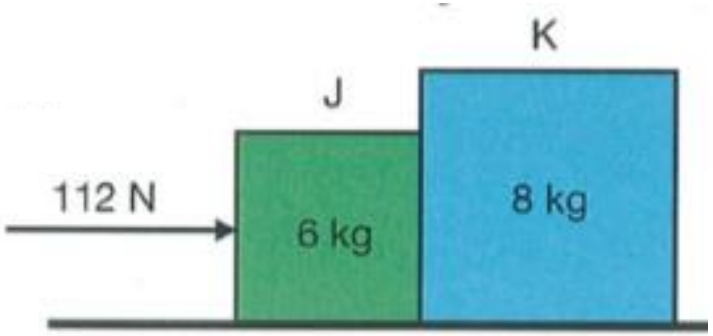
Net force on Y = $m_Y a$

= 5000 x 0.5

So F_Y = 2500 N right

Q2

(a) The acceleration of the system.
(b) The acceleration of each object.
(c) The net force on each object.
(d) The value of the action/reaction force pair at each contact surface.



(a) $a = 112/(6 + 8) = 8\ \text{m s}^{-2}$ right
(b) $8\ \text{m s}^{-2}$ right
(c) $F_J = 6 \times 8 = 48$ N right, $F_K = 8 \times 8 = 64$ N right
(d) 64 N (both directions)

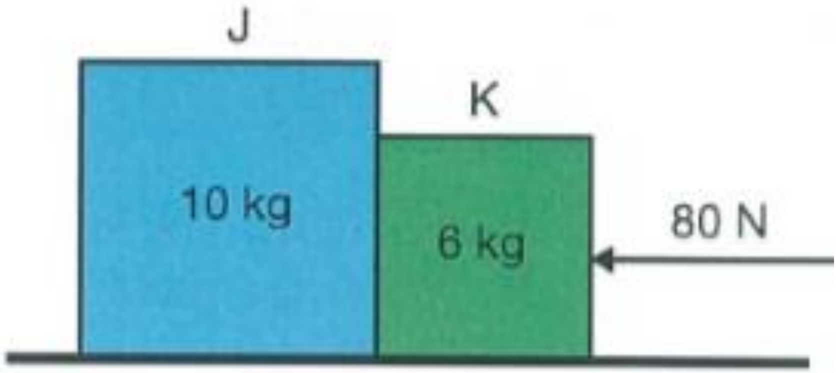
Q3

(a) The acceleration of the system.

(b) The acceleration of each object.

(c) The net force on each object.

(d) The value of the action/reaction force pair at each contact surface.



(a) $a = 80/(10 + 6) = 5\ \text{m s}^{-2}$ left

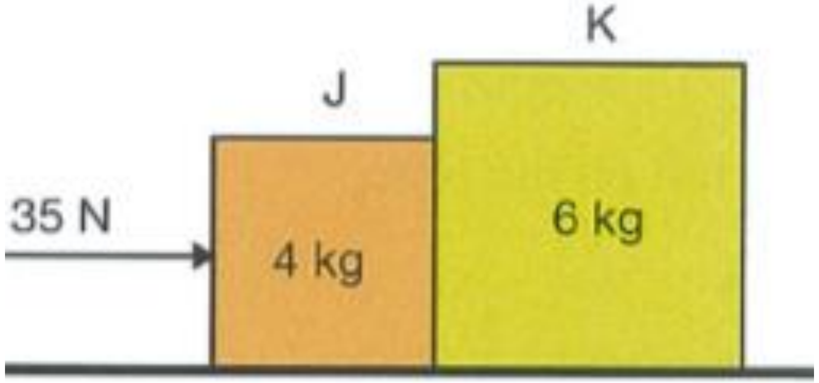
(b) $5\ \text{m s}^{-2}$ left

(c) $F_J = 10 \times 5 = 50$ N left, $F_K = 6 \times 5 = 30$ N left

(d) 50 N (both directions)

Q4

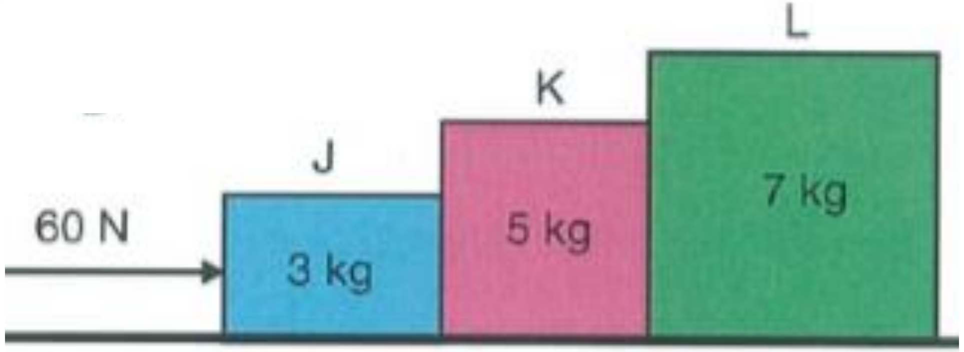
(a) The acceleration of the system.
(b) The acceleration of each object.
(c) The net force on each object.
(d) The value of the action/reaction force pair at each contact surface.



(a) $a = 35/(4 + 6) = 3.5\text{ m s}^{-2}$ right
(b) 3.5 m s^{-2} right
(c) $F_J = 4 \times 3.5 = 14$ N right, $F_K = 6 \times 3.5 = 21$ N right
(d) 21 N (both directions)

Q5

(a) The acceleration of the system.
(b) The acceleration of each object.
(c) The net force on each object.
(d) The value of the action/reaction force pair at each contact surface.



(a) $a = 60/(3 + 5 + 7) = 4 \text{ m s}^{-2}$ right
(b) 4 m s^{-2} right
(c) $F_J = 3 \times 4 = 12$ N, $F_K = 5 \times 4 = 20$ N, $F_L = 7 \times 4 = 28$ N (all right)
(d) $F_{JK} = (5 + 7) \times 4 = 48$ N, $F_{KL} = 7 \times 4 = 28$ N (both directions)

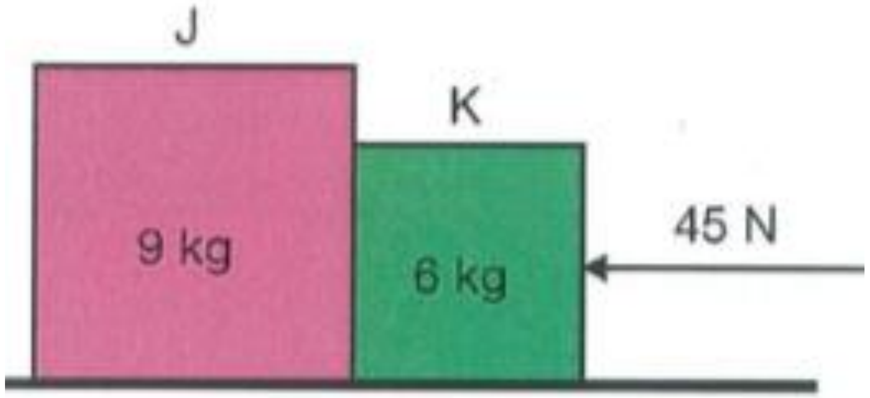
Q6

(a) The acceleration of the system.

(b) The acceleration of each object.

(c) The net force on each object.

(d) The value of the action/reaction force pair at each contact surface.



(a) $a = 45/(9 + 6) = 3\ \text{m s}^{-2}$ left

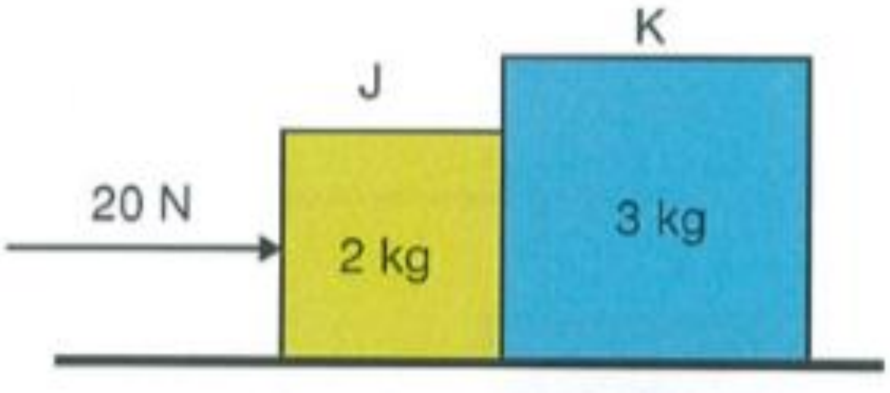
(b) $3\ \text{m s}^{-2}$ left

(c) $F_J = 9 \times 3 = 27$ N left, $F_K = 6 \times 3 = 18$ N left

(d) 27 N (both directions)

Q7

(a) The acceleration of the system.
(b) The acceleration of each object.
(c) The net force on each object.
(d) The value of the action/reaction force pair at each contact surface.



(a) $a = 20/(2+3) = 4\ \text{m s}^{-2}$ right
(b) $4\ \text{m s}^{-2}$ right
(c) $F_J = 2 \times 4 = 8$ N right, $F_K = 3 \times 4 = 12$ N right
(d) 68 N (both directions)

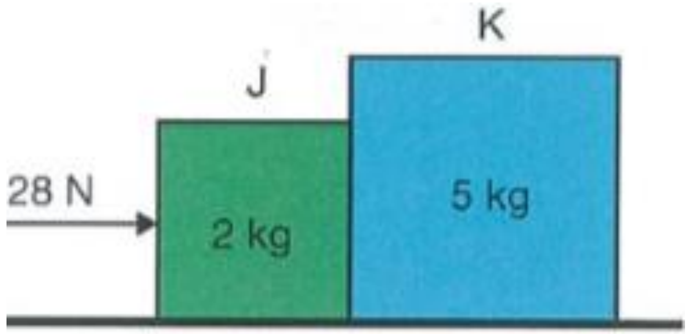
Q8

(a) The acceleration of the system.

(b) The acceleration of each object.

(c) The net force on each object.

(d) The value of the action/reaction force pair at each contact surface.



(a) $a = 28/(2 + 5) = 4$ m s^{-2} right

(b) 4 m s^{-2} right

(c) $F_J = 2 \times 4 = 8$ N right, $F_K = 5 \times 4 = 20$ N right

(d) $F_{JK} = 36$ N (both directions)

Q9

(a) The acceleration of the system.

(b) The acceleration of each object.

(c) The net force on each object.

(d) The value of the action/reaction force pair at each contact surface.

(a) $a = 36/(4 + 5 + 3) = 3$ m s^{-2} left

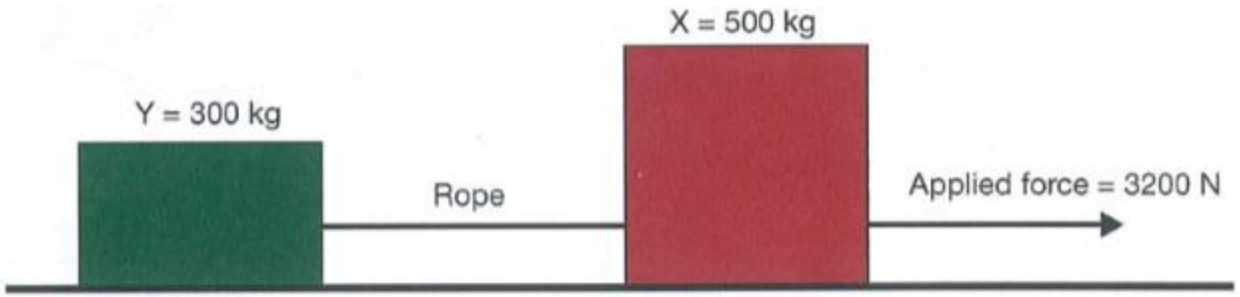
(b) 3 m s^{-2} left

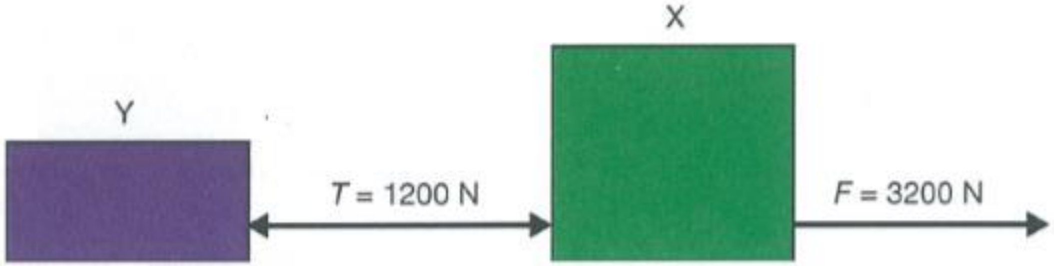
(c) $F_J = 4 \times 3 = 12$ N, $F_K = 5 \times 3 = 15$ N, $F_L = 3 \times 3 = 9$ N (all left)

(d) $F_{JK} = 4 \times 3 = 12$ N, $F_{KL} = (3 + 5) \times 3 = 24$ N (both directions)

Q10

Consider a force of 320 N pulling block X which has a mass of 500 kg and is connected to block Y, mass 300 kg, by rope 2. The blocks are resting on a frictionless surface. The diagram summarises the situation. Find the acceleration of the system and of each mass, the net force acting on each mass and the tension in the rope.





$F = ma$

$3200 = 800a$

So $a = 4\ \mathrm{m\ s^{-2}}$ to the right

$F_X = m_X a$

$= 500 \times 4$

$= 2000$ N to the right

$F_Y = m_Y a$

$= 300 \times 4$

$= 1200$ N to the right

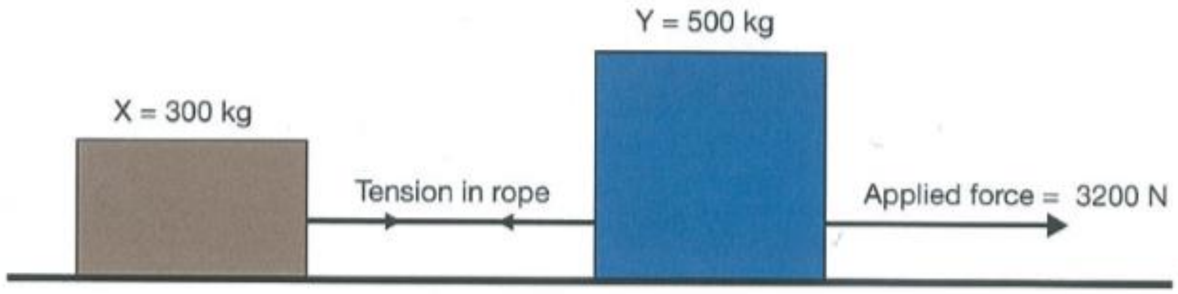
The 1200 N force on Y is applied by the rope connecting it to X, so the tension in the rope will be 1200 N.

The applied force on X is 3200 N (right). The net force on X is only 2000 N. So there must be another force of 1200 N acting on X to the left. This is the force supplied by the tension in the rope connecting X to Y. **Tension in ropes and cables act in both directions.**

Q10 Alternative

This situation can also be analysed by writing force equations for each mass.

To do this we label all the forces acting in the system. We ignore weight force and the reaction to the weight force as motion is horizontal. The diagram shows the forces.



Because the tension in each rope acts on the object connected to it at each end the tensions are labelled in each rope twice.

Write force equations for each mass.

For X: Net force = $m_X a$ = applied force – T

For Y: Net force = $m_Y a = T$ (only T acts on block Y)

Substituting the appropriate values: For X: Net force = $500a = 3200 - T$ (Equation 1)

For Y: Net force = $300a = T$ (Equation 2)

Solving simultaneously: $800a = 3200$

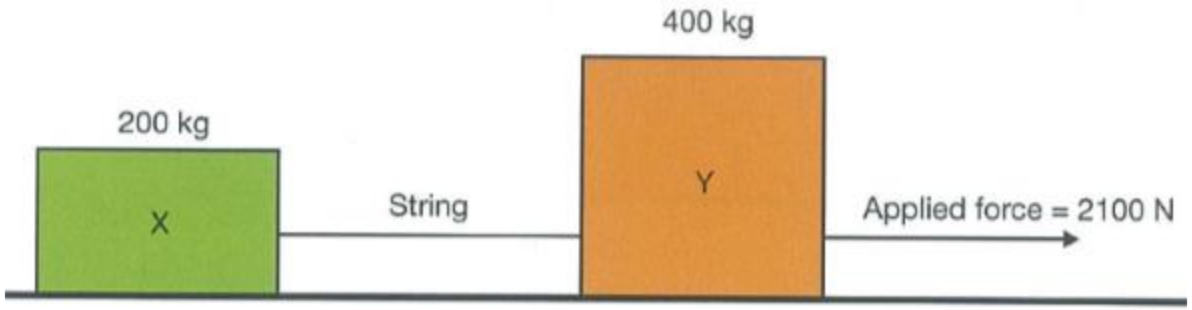
Therefore $a = 4$ m s^{-2} to the right

Substituting back into equation 2: $300 \times 4 = T$

Therefore $T = 1200$ N (acting both ways in the rope)

Q11

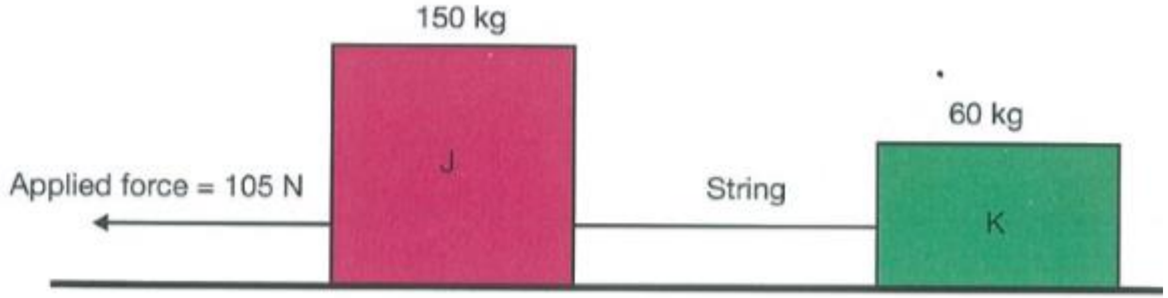
(a) The acceleration of the system.
(b) The acceleration of each object.
(c) The net force on each object.
(d) The tension in each string or rope.



(a) $a = F/m = 2100/(200 + 400) = 3.5\ \text{m s}^{-2}$ to the right
(b) Both $3.5\ \text{m s}^{-2}$ to the right
(c) $F_X = ma = 200 \times 3.5 = 700$ N, $F_Y = 400 \times 3.5 = 1400$ N both to the right
(d) $T = F_X = 700$ N (both directions)

Q12

(a) $a = 105/(150 + 60) = 0.5$ m s^{-2} to the left
(b) Both 0.5 m s^{-2} to the left
(c) $F_J = 150 \times 0.5 = 75$ N, $F_K = 60 \times 0.5 = 30$ N both to the left
(d) $T = F_K = 30$ N (both directions)



(a) $a = 105/(150 + 60) = 0.5$ m s^{-2} to the left
(b) Both 0.5 m s^{-2} to the left
(c) $F_J = 150 \times 0.5 = 75$ N, $F_K = 60 \times 0.5 = 30$ N both to the left
(d) $T = F_K = 30$ N (both directions)