DYNAMICS : APPLICATION OF NEWTON'S LAWS

Q. The diagram below shows an object of mass 2kg attached to a string. Assume $g = 10ms^{-2}$.

(i) Mark the forces on the diagram

Done

(ii) What is tension?

Tension is the name given to a force which is experienced by a rope, string, chain, thread, etc.

(iii) How to mark the direction of tension?

Tension is always directed away from the concerned object.

(iv) Calculate tension if the object is at rest.

Forces = balanced

$\therefore, T = 20N$

(v) Calculate tension if the object moves at constant velocity

Since velocity is constant, the acceleration must be zero and the forces must be balanced.

$\therefore, T = 20N$

(vi) Calculate tension if the object accelerates upwards at $2ms^{-2}$

Upward acceleration implies that the upwards force must be greater than the downwards force.

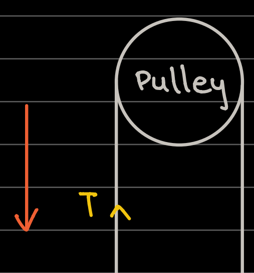
$$T - 20 = ma$$
$$T - 20 = (2)(2)$$
$$T - 20 = 4$$
$$\therefore, T = 24N$$

(vii) Calculate tension if the object accelerates downwards at $5ms^{-2}$.

Downward resultant force

$$20 - T = ma$$
$$20 - T = (2)(5)$$
$$20 - T = 10$$
$$\therefore, 10N = T$$

Q.

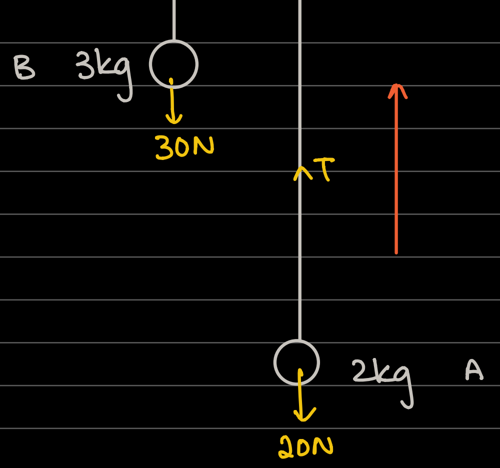


(i) Mark weight and tension.

Done

(ii) The system is released from rest from the position shown

(a) Calculate acceleration



B (acc. downwards)

$F = ma$

$30 - T = (3)(a)$

$30 - T = 3a$ (1)

A (acc. upwards)

$F = ma$

$T - 20 = 2a$ (2)

Solving simultaneously

$30 - 3a = T$

$30 - 3a - 20 = 2a$

$10 = 5a$

$2 = a$

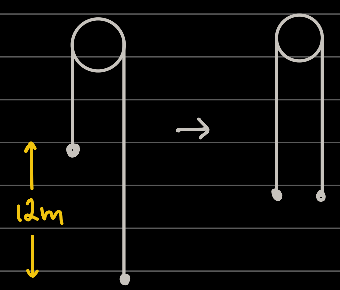
$30 - 3(2) = T$

$30 - 6 = T$

$24 = T$

$\therefore$, $T = 24N$ and $a = 2ms^{-2}$

(iii) Given that initially they were seperated by 12m, calculate their speed when they cross each other



$u = 0$

$v = ?$

$a = 2$

$s = 6$

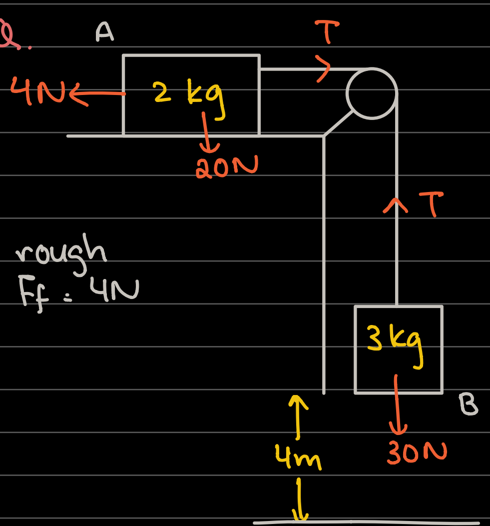
$v^2 = u^2 + 2as$

$v^2 = 2(2)(6)$

$v^2 = 24$

$v = 4.9ms^{-3}$ → Ans

Q.



rough

Ff : 4N

(i) Mark the forces

(ii) Calculate 'a' and 'T'

For B : $F = ma$

$30 - T = ma$

$30 - T = 3a$ (1)

For A : $F = ma$

$T - 4 = 2a$ (2)

Solve simultaneously

$30 - T = 3\left(\frac{T - 4}{2}\right)$

$60 - 2T = 3T - 12$

$\frac{72}{5} = \frac{5T}{5}$

$14.4 = T$

$T - 4 = 2a$

$14.4 - 4 = 2a$

$10.4 = 2a$

$5.2 = a$

ms^{-2}

$\therefore$, $a = 5.2$ and $T = 14.4N$

(iii) Given that system is released from rest, calculate speed of B as it reaches the ground

for B :

$u = 0$

$v = ??$

$a = 5.2$

$s = 4$

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

$v^2 = 2(5.2)(4)$

$v = 6.45ms^{-1}$

(iv) After B hits the ground (ie it stops moving), the string will become slack (ie. $T=0$) as A continues to move to the right. Due to friction, A will decelerate until it comes to rest. Calculate its deceleration and the distance it travels until it comes to rest.

A will decelerate only bc. of friction.
It will initially have an acceleration of 5.2, then suddenly negative acceleration until it comes to a stop.

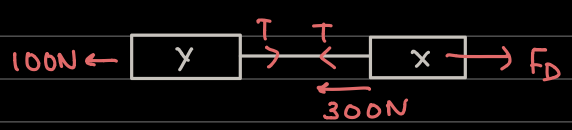
$F = ma$ $\therefore$, deceleration is $2ms^{-2}$
$-4 = 2a$
$-2 = a$

$v = 0$
$u = 6.45$ (from part ii)
$s = ??$
$a = -2ms^{-2}$

$v^2 = u^2 + 2as$
$0 = (6.45)^2 + 2(-2)s$
$0 = 41.6 - 4s$
$\frac{4s}{4} = \frac{41.6}{4}$
$s = 10.4 \rightarrow \underline{Am}$

$\therefore$, deceleration is $2ms^{-2}$ and $s = 10.4m$ until it comes to rest

Q. The diagram below shows a tractor (x) of mass = 1000kg pulling a trailer (y) of mass = 500kg. The F_f on X is 300N and F_f on Y is 100N. The driving force of X is F_D.



i) Calculate F_D and T if system moves at constant velocity

For Y $T = 100N$
For X $F_D = T + 300$ $\therefore$, $F_D = 400N$

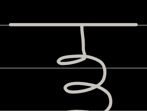
ii) Calculate F_D and T if system accelerates at $4ms^{-2}$

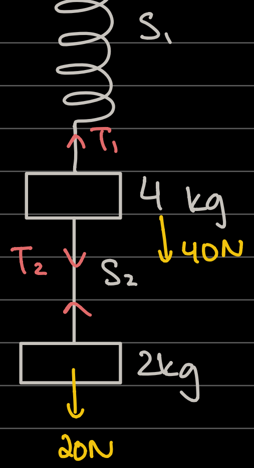
For X $F = ma$
$F_D - T - 300 = 1000(4)$

For Y $F = ma$

COMPLETE THIS

Q. A spring S_1 is connected to a 4kg mass. A string S_2 joins the 4kg with the 2kg mass. (as shown)





(i) Calculate tension T_1 in S_1 and tension T_2 in S_2 if the system is at rest

For 2kg: forces balanced, so $T_2 = 20N$

For 4kg: forces balanced $T_1 = T_2 + 40$

$T_1 = 20 + 40$

$T_1 = 60N$

(ii) The string S_2 is cut. Calculate the upward acceleration of the 4kg mass.

After string is cut, $T_2 = 20N$ no longer exists, so the only downward force acting on the 4kg mass is it's weight, 40N.

upward force = $60 - 40 = 20$

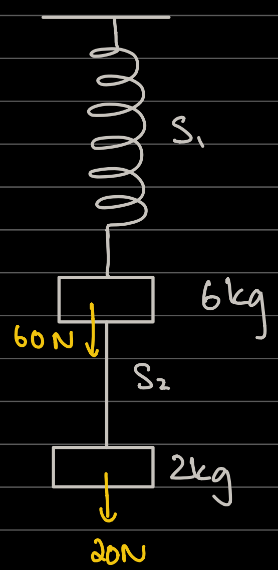
$F = ma$

$20 = 4a$

$5 = a$

∴, upward acceleration $= 5ms^{-2}$

Q.



Initially, the system is at rest.
Some time later, the string is cut.
Calculate the upward acceleration of the 6kg mass

Upwards = 80N
Downwards = 60N

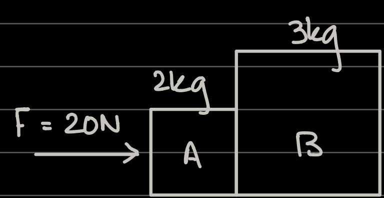
$80 - 60 = 6a$

$20 = 6a$

$3.3 = a$

∴, $a = 3.3ms^{-2}$

How to calculate action/reaction forces based on Newton's 3rd Law.



(i) For the given diagram, calculate the acceleration of the system

$F = ma$

$20 = 5a$

$4 = a$

∴, $a = 4ms^{-2}$

(ii) Calculate the force X which A exerts on B based on Newton's 3rd law.

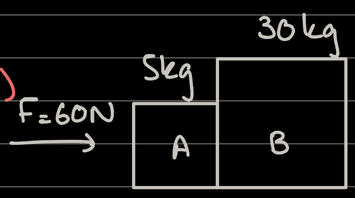
$F = ma$
$F = (2)(4)$
$F = 8N.$

$20N - 8N = 12N$

$F = ma$
$X = (3)(4)$
$X = 12N$

$\therefore,\ X = 12N.$

(iii)



Find the force which A exerts on B.

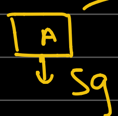
$F = ma$
$60 = 35a$
$a = 1.71$

$F = ma$
$F = (30)(1.71)$
$F = 54.1$

"Shortcut" $\rightarrow \left[\dfrac{m_B}{m_A + m_B}\right] \times$ total force

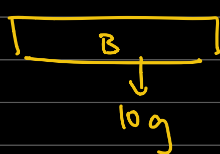
Q.

They fall freely $(a = g)$, calculate the force which B exerts on A.



$F = ma$
$5g - x = 5g$
$x = 0$

Conclusion; in free fall there is no need to calculate the force as they do not exert a force on each other.



$F = ma$
$x + 10 = 10g$
$x = 0N$