KEY

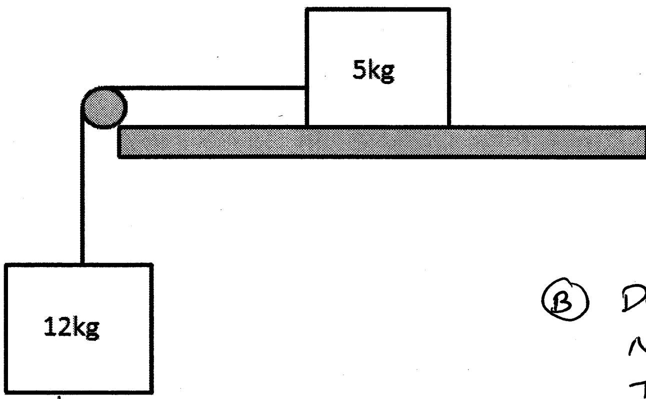
First Name:______________________________ Last Name:______________________________

L08 – Worksheet – Systems with Pulleys

Section #1: Systems with Pulleys (no friction)

Q1: A 5kg block is sitting on a frictionless table. The 12kg block is released.

a) What is the force of gravity on the 12kg block?
b) What is the acceleration of the *system of masses*?
c) Draw a *Free-Body-Diagram* for the 5kg mass.
d) What is the tension in the rope?



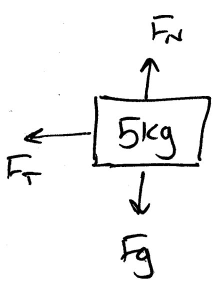
(A)

$F_g = mg$
$= (12\,kg)(9.81\,m/s^2)$
$= 117.72\,N$

(B) Driving force is 117.72 N.
No force opposing it (no friction).
Therefore Net Force is 117.72 N

$\vec{a} = \frac{F_{net}}{m} = \frac{117.72\,N}{17\,kg} = 6.92\,m/s^2$

(C)



(D) $\vec{a} = \frac{F_{net}}{m}$

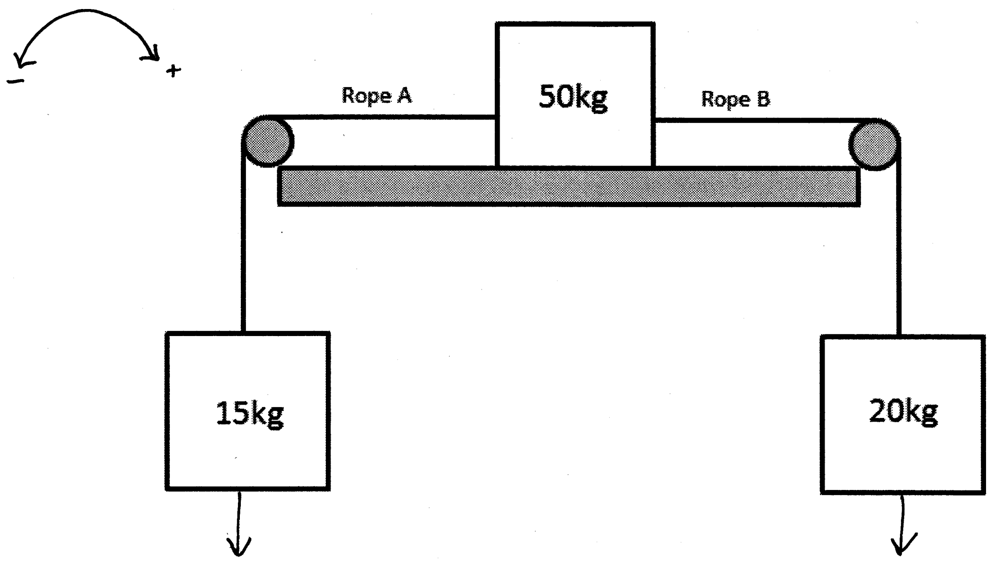
$\vec{F}_{net} = m\vec{a}$
$= (5\,kg)(6.92\,m/s^2)$
$= 34.6\,N$

Since $\vec{F}_{net} = \vec{F}_T$ (and no friction)
$\vec{F}_T = 34.6\,N$

[redacted] Key [redacted]

Q2: A 50kg block is sitting on a frictionless surface. The system of masses is released.

a) How quickly will the system of masses accelerate?
b) What is the tension in Rope A?
c) What is the tension in Rope B?



$F_g = mg$
$= (15kg)(9.81 m/s^2)$
$= 147.15N$

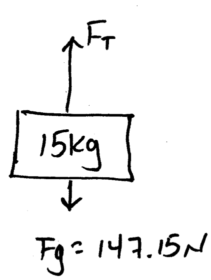
$F_g = mg$
$= (20kg)(9.81 m/s^2)$
$= 196.2 N$

(A) Driving force of system is 196.2N.
Opposing force is 147.15N

$\vec{F}_{net} = \vec{F}_1 + \vec{F}_2$
$= (+196.2N) + (-147.15N)$
$= 49.05N$ [forward]

$\vec{a} = \frac{\vec{F}_{net}}{m_{sys}} = \frac{49.05N}{85kg} = 0.577 m/s^2$ [forward]

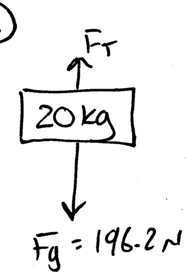
(B)



$F_{net} = ma$
$= (15kg)(0.577 m/s^2)$
$= 8.655N$ [f]

$\vec{F}_{net} = \vec{F}_T + \vec{F}_g$
$8.655N = (F_T) + (-147.15N)$
$F_{T_{Rope A}} = 155.805N$

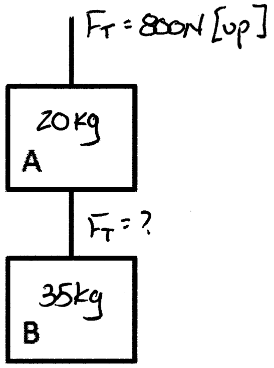
(C)



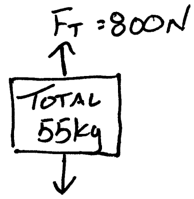
$F_{net} = ma = (20kg)(0.577 m/s)$
$= 11.54N$ [f]
$\vec{F}_{net} = \vec{F}_T + \vec{F}_g$
$11.54N = F_T + (+196.2N)$
$F_T = -184.66N$

KEY

Q3: If m_A = 20kg and m_B = 35kg, and a person at the top is pulling the blocks upward with a force of 800N, what is the tension in the rope connecting the two blocks?



System

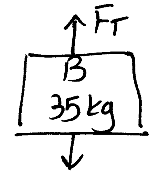


$F_g = mg$
$= (55kg)(9.81 m/s^2)$
$= 539.55N$

$\vec{F}_{net} = \vec{F}_{app} + \vec{F}_g$
$= (800N) + (-539.55N)$
$= 260.45N$ [up]

$\vec{a} = \frac{\vec{F}_{net}}{m} = \frac{260.45N [up]}{55kg} = 4.74 m/s^2$ [up]

Block B only



$F_g = mg = (35kg)(9.81 m/s^2)$
$= 343.35N$

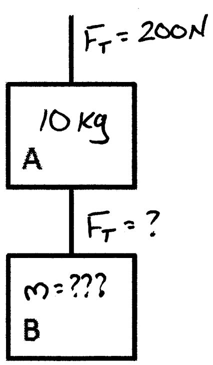
$\vec{F}_{net} = m\vec{a}$
$= (35kg)(4.74 m/s^2)$
$= 165.74N$

$\vec{F}_{net} = \vec{F}_T + \vec{F}_g$
$165.74N = F_T + (-343.35N)$
$F_T = 509.1N$

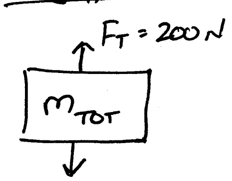
HARD

+ ↑ ↓ −

Q4: A person is gently lowering two blocks to the ground by applying a force of 200N [upward]. If the system is accelerating downward at 2.3 m/s², and m_A = 10kg, what is tension in the rope connecting the two blocks?



System



$F_g = mg$

$\vec{F}_{net} = \vec{F}_T + \vec{F}_g$

$m\vec{a} = 200N + m(-9.81)$

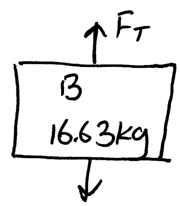
$-2.3m = 200 - 9.81m$
$+9.81m \qquad +9.81m$

$7.51m = 200$

$m_{sys} = 26.63kg$

This is total mass, so
$m_B = 16.63kg$

Block B only



$F_g = mg = (16.63kg)(9.81 m/s^2)$
$= 163.14N$

$\vec{F}_{net} = m\vec{a}$
$= (16.63kg)(-2.3 m/s^2)$
$= 38.249N$ [down]

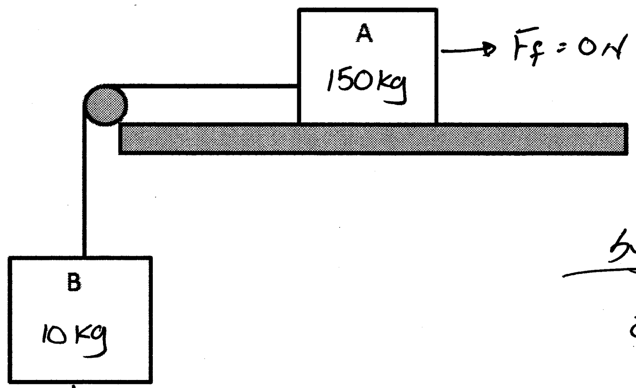
$\vec{F}_{net} = \vec{F}_T + \vec{F}_g$

$-38.249N = F_T - 163.14N$

$F_T = 124.89N$

KEY

Q5: If m_A = 150kg, m_B = 10kg, and there is no friction between block A and the table, what is the acceleration of the system?



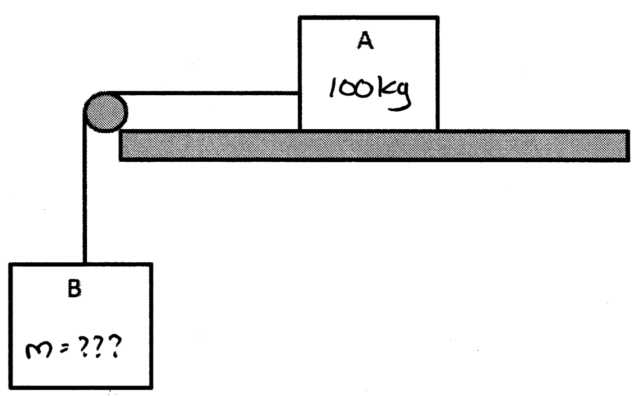
$F_g = mg$
$= (10kg)(9.81 m/s^2)$
$= 98.1N$

This force is accelerating the system.

System

$\vec{a} = \frac{\vec{F}_{net}}{m} = \frac{98.1N}{160kg} = 0.61 m/s^2$ [forward]

Q6: If the tension between block A (100kg) and block B (unknown mass) is 196.2N, and the system accelerates at 1.962m/s², what is the mass of block B, m_B? F_T



FBD of Block B

196.2 N
B
$F_g = mg$
$= 9.81m$

− / +

$\vec{F}_{net} = \vec{F}_g + \vec{F}_T$

$1.962m = 9.81m + (-196.2)$

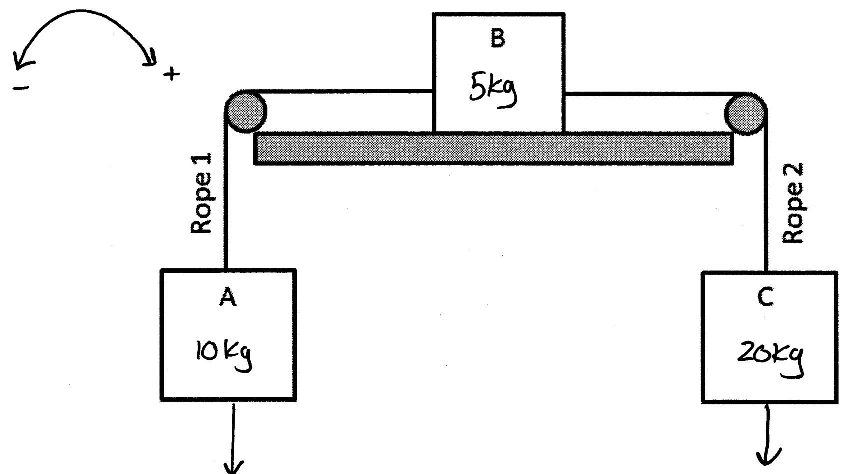
$-7.848m = -196.2$

$m = 25kg$

KEY

LONG

Q7: If m_A = 10kg, m_B = 5kg, and m_C = 20kg, what is the tension in each rope?



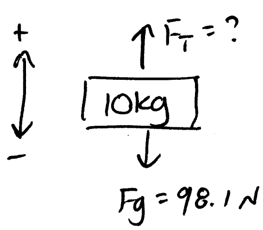
① $F_g = mg = (10kg)(9.81 m/s^2) = 98.1 N$

① $F_g = mg = (20kg)(9.81 m/s^2) = 196.2 N$

② $F_{net} = 196.2 N - 98.1 N = 98.1 N$ [forward]

③ $a_{sys} = \frac{F_{net}}{m_{sys}} = \frac{98.1 N}{35 kg} = 2.8 m/s^2$ [forward]

④ Block A



$F_{net} = F_T + F_g$

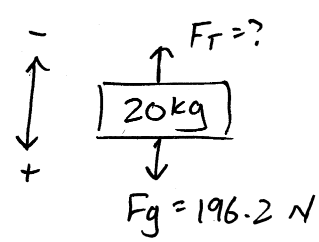
$ma = F_T - 98.1 N$

$(10kg)(2.8 m/s^2) = F_T - 98.1$

$28 = F_T - 98.1$

$F_{T_{Left}} = 126.1 N$

⑤ Block B



$F_{net} = F_T + F_g$

$ma = F_T + 196.2N$

$(20kg)(2.8 m/s^2) = F_T + 196.2 N$

$56 = F_T + 196.2 N$

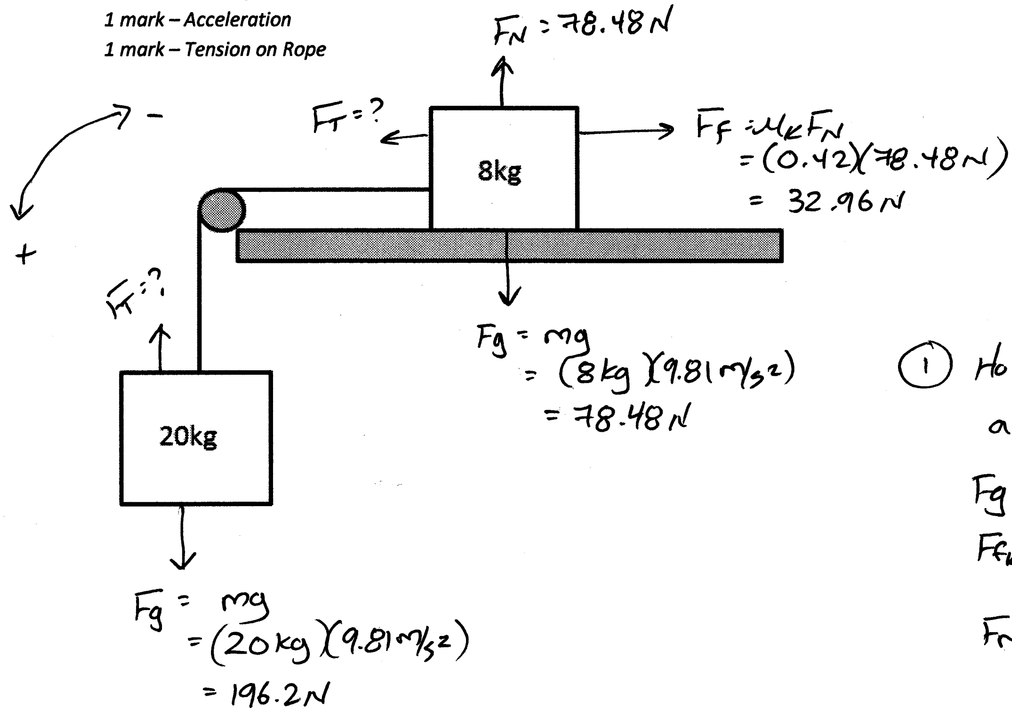
$F_{T_{Right}} = -140.2 N$

KEY

Section #2: Systems with Pulleys (with friction)

Q8: A series of blocks are connected via cables. The 20kg block is allowed to fall, which in turn drags the 8kg block sideways. If the coefficient of kinetic friction is 0.42, what is the tension in the rope? *(4 marks)*

1 mark – Force of Gravity
1 mark – Force of Friction
1 mark – Acceleration
1 mark – Tension on Rope



① How quickly does the system accelerate?

$F_g = 196.2N$ pulling in one direction.
$F_{fk} = 32.96N$ resisting the movement.

$F_{net} = F_g + F_{fk}$
$= (196.2N) + (-32.96N)$
$= 163.24N$ [forward]

$a = \frac{F_{net}}{m_{sys}} = \frac{163.24N}{28 kg} = 5.83 m/s^2$ [f

② Option - FBD 20kg mass

F_T ↑ [20kg] ↓ $F_g = 196.2N$

$F_{net} = ma$
$= (20kg)(5.83 m/s^2)$
$= 116.6N$ [forward]

$F_{net} = F_g + F_T$
$116.6N = 196.2N + F_T$
$F_T = -79.6N$

② Option - FBD 8kg mass

F_T ← [8kg] → $F_f = 32.96N$

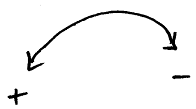
$F_{net} = ma$
$= (8kg)(5.83 m/s^2)$
$= 46.64N$ [forward]

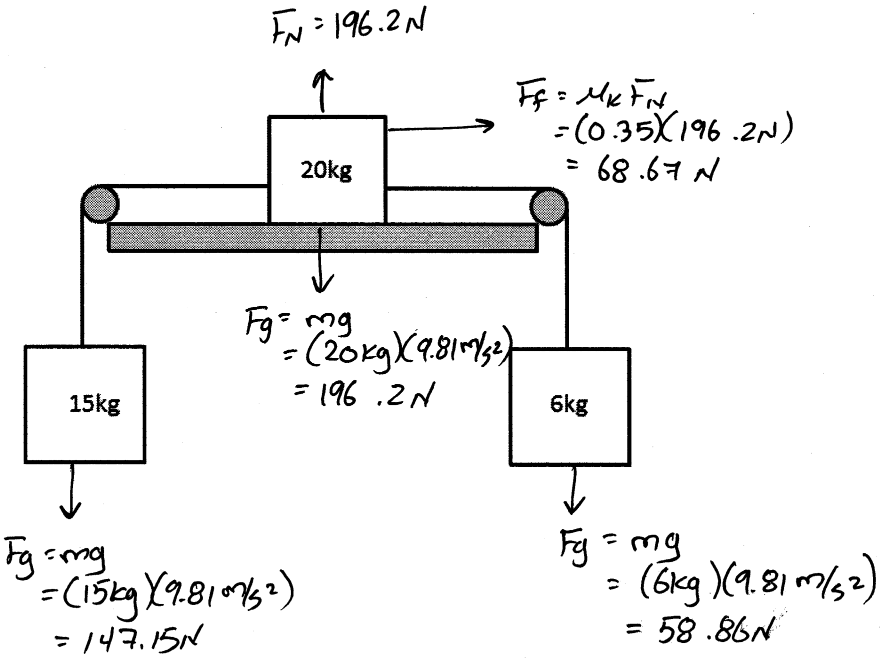
$F_{net} = F_T - F_{fk}$
$46.64N = F_T - 32.96N$
$F_T = 79.6N$ [forward]

KEY

Q9: A series of blocks are connected via cables. The blocks are released and the system starts to accelerate. If the coefficient of kinetic friction between the 20kg block and the table is 0.35, what is the tension in the **LEFT** rope? *(5 marks)*

1 mark – Force of Friction
1 mark – Force of Gravities on 15kg and 6kg
1 mark – Net Force
1 mark – Acceleration of System
*1 mark – Tension on **LEFT** Rope*





① $\vec{F}_{net} = \vec{F}_1 + \vec{F}_2 + \vec{F}_3$

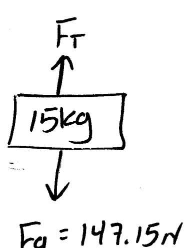
$= F_{g15} + F_{g6} + F_{fk}$

$= (147.15) + (-58.86) + (-68.67)$

$= 19.62\ N$

② $\vec{a} = \dfrac{\vec{F}_{net}}{m_{sys}} = \dfrac{19.62\ N}{41\ kg} = 0.479\ m/s^2\ [f]$

③ FBD for 15kg object



$\vec{F}_{net} = m\vec{a}$

$= (15kg)(0.479\ m/s^2)$

$= 7.185N\ [f]$

$F_{net} = F_g + F_T$

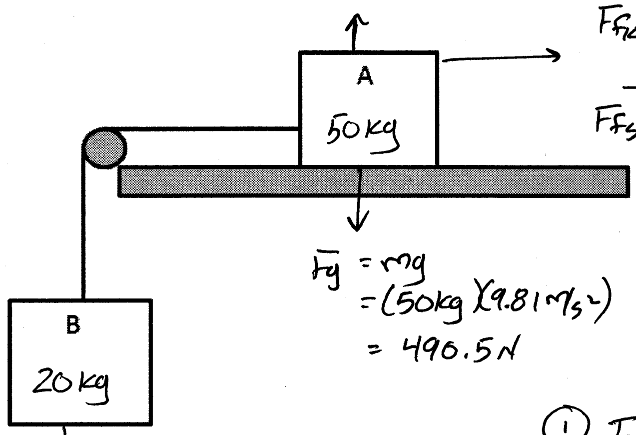
$7.185 = (147.15) + F_T$

$F_T = -139.965\ N$

KEY

Q10: If m_A = 50kg, m_B = 20kg, and μ_s = 0.8, and μ_k = 0.25, under what conditions would the system accelerate? Explain.

$F_N = 490.5N$



$F_{fk} = \mu_k F_N = (0.25)(490.5N) = 122.625N$

or

$F_{fs} = \mu_s F_N = (0.8)(490.5N) = 392.4N$

$F_g = mg$
$= (50kg)(9.81 m/s^2)$
$= 490.5N$

$F_g = mg$
$= (20kg)(9.81 m/s^2)$
$= 196.2N$

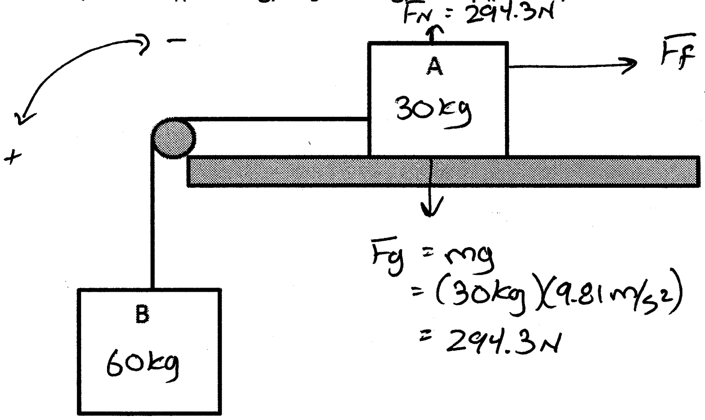
Accelerates the system.

① If stationary to begin with, the hanging mass does not provide enough force to overcome static friction. System will not accelerate.

② If already moving, hanging mass overcomes kinetic friction, so system will accelerate.

Q11: If m_A = 30kg, m_B = 60kg, and μ_k = 1.2, what is the tension in the rope?

$F_N = 294.3N$



$F_f = \mu_k F_N$
$= (1.2)(294.3N)$
$= 353.16N$

$F_g = mg$
$= (30kg)(9.81 m/s^2)$
$= 294.3N$

$F_g = mg$
$= (60kg)(9.81 m/s^2)$
$= 588.6N$

① System

$\vec{a} = \frac{\vec{F}_{net}}{m_{sys}} = \frac{(588.6 - 353.16)}{90 kg}$

$= 2.616 m/s^2$ [forward]

② FBD for Block A

$F_T \leftarrow$ [30kg] $\rightarrow F_f = 353.16N$

$F_{net} = F_T + F_f$
$m(2.616) = F_T + (-353.16)$
$78.48 = F_T - 353.16$
$F_T = 431.6N$