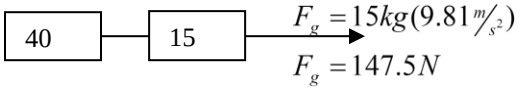
Physics 20 - Lesson 18
Dynamics – Pulleys and Systems

Possible 125 / 71

1)



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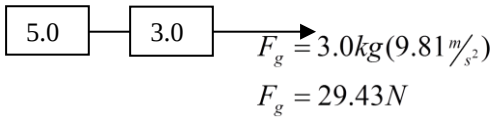
$\vec{F}_{net} = m\vec{a}$

$\vec{F}_{g15} = (m_1 + m_2)\vec{a}$

$+147.15N = (40kg + 15kg)\vec{a}$

$\boxed{\vec{a} = 2.68\,^m/_{s^2}}$

2)



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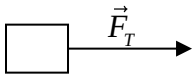
calculate acceleration first

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

$+29.43N = (8.0kg)\vec{a}$

$\boxed{\vec{a} = +3.68\,^m/_{s^2}}$

using the 5.0 kg block

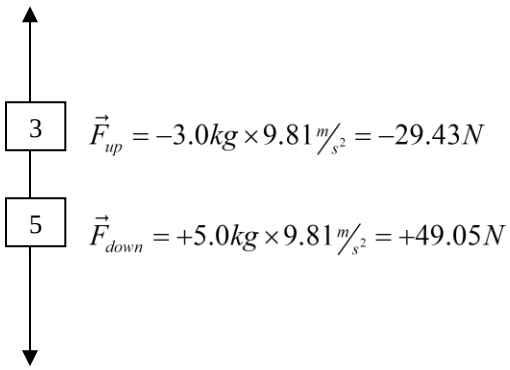


$\vec{F}_{net} = m\vec{a}$

$\vec{F}_T = 5.0kg(+3.68\,^m/_{s^2})$

$\boxed{\vec{F}_T = +18.4N}$

3)



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acceleration

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

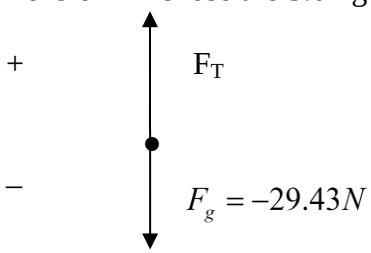
$\vec{F}_{down} + \vec{F}_{up} = (m_1 + m_2)\vec{a}$

$+49.05N + (-29.43N) = (3.0kg + 5.0kg)\vec{a}$

$+19.62 = 8.0\vec{a}$

$\boxed{\vec{a} = +2.45\,^m/_{s^2}}$

Tension – I chose the 3.0 kg mass



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

$\vec{F}_T + \vec{F}_g = m\vec{a}$

$\vec{F}_T + (-29.43N) = 3.0kg(+2.45\,^m/_{s^2})$

$\boxed{\vec{F}_T = +36.8N}$

4)

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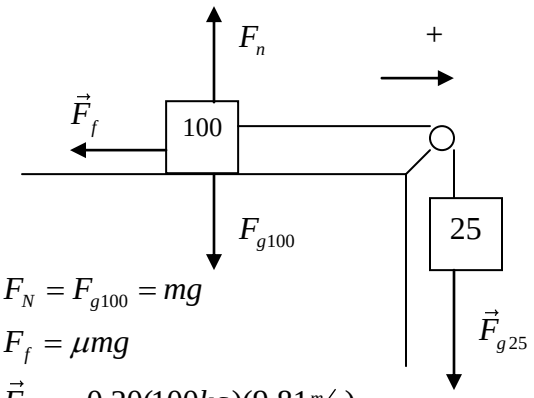


$F_N = F_{g100} = mg$

$F_f = \mu mg$

$\vec{F}_f = -0.20(100kg)(9.81\,^{m}/_{s^2})$

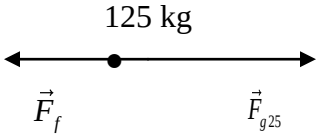
$\boxed{\vec{F}_f = -196.2N}$

$F_{g25} = mg$

$\vec{F}_{g25} = +25kg(9.81\,^{m}/_{s^2})$

$\boxed{\vec{F}_{g25} = +245.25N}$

Acceleration



$\vec{F}_{net} = \vec{F}_{g25} + \vec{F}_f$

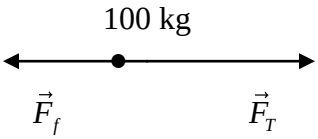
$\vec{F}_{net} = +245.25N + (-196.2N)$

$\vec{F}_{net} = +49.05N$

$\vec{a} = \dfrac{\vec{F}_{net}}{m} = \dfrac{+49.05N}{125kg}$

$\boxed{\vec{a} = +0.3924\,^{m}/_{s^2}}$

Tension



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

$\vec{F}_T = \vec{F}_{net} - \vec{F}_f$

$\vec{F}_T = m\vec{a} - \vec{F}_f$

$\vec{F}_T = 100kg(+0.3924\,^{m}/_{s^2}) - (-196.2N)$

$\boxed{\vec{F}_T = +235.4N}$

5)

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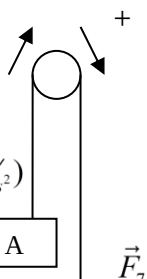


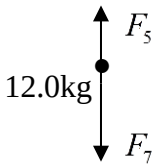
$\vec{F}_5 = -5.0kg(9.81\,^{m}/_{s^2})$

$\vec{F}_5 = -49.05N$

$\vec{F}_7 = +7.0kg(9.81\,^{m}/_{s^2})$

$\vec{F}_7 = +68.67N$

Acceleration



$\vec{F}_{net} = \vec{F}_7 + \vec{F}_5$

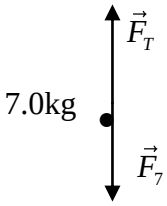
$\vec{F}_{net} = +68.67N + (-49.05N)$

$\vec{F}_{net} = +19.62N$

$\vec{a} = \dfrac{\vec{F}_{net}}{m} = \dfrac{+19.62N}{(7.0kg + 5.0kg)}$

$\boxed{\vec{a} = +1.635\,^{m}/_{s^2}}$

Tension



$\vec{F}_{net} = \vec{F}_7 + \vec{F}_T$

$\vec{F}_T = \vec{F}_{net} - \vec{F}_7$

$\vec{F}_T = m\vec{a} - \vec{F}_7$

$\vec{F}_T = 7.0kg(+1.635\,^{m}/_{s^2}) - 68.67N$

$\boxed{\vec{F}_T = -57.2N}$

6) The force on each girl will be equal (360N) but opposite in direction

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a) $\vec{a}_1 = \frac{\vec{F}_{net}}{m_1} = \frac{+360N}{40kg}$ $\quad \vec{a}_2 = \frac{\vec{F}_{net}}{m_2} = \frac{-360N}{60kg}$

$\boxed{\vec{a}_1 = 9.0\,^{m}/_{s^2}}$ $\quad \boxed{\vec{a}_1 = -6.0\,^{m}/_{s^2}}$

b) $\vec{v}_2 = \vec{v}_1 = \vec{a}\Delta t$ $\quad \vec{v}_2 = 0 - 6.0\,^{m}/_{s^2}(0.10s)$

$\vec{v}_2 = 0 + 9.0\,^{m}/_{s^2}(0.10s)$ $\quad \boxed{\vec{v}_2 = -0.60m/s}$

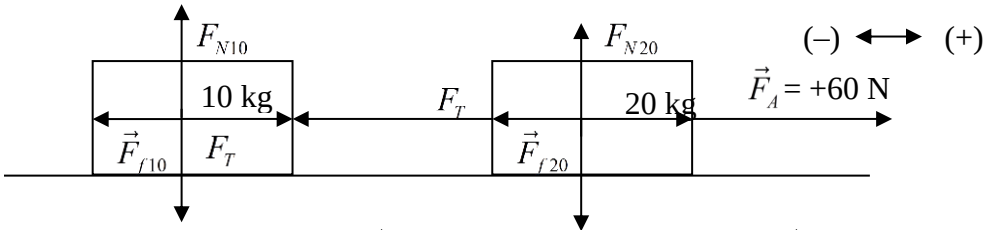
$\boxed{\vec{v}_2 = +0.90m/s}$

c) $\Delta\vec{d} = \frac{1}{2}\vec{a}\Delta t^2$ $\quad \Delta\vec{d} = \frac{1}{2}(-6.0\,^{m}/_{s^2})(0.10s)^2$

$\Delta\vec{d} = \frac{1}{2}(9.0\,^{m}/_{s^2})(0.10s)^2$ $\quad \boxed{\Delta\vec{d} = -0.030m}$

$\boxed{\Delta\vec{d} = 0.045m}$

7)



$F_{N10} = F_{g10} = 10kg(9.81\,^{m}/_{s^2})$ $\quad F_{N20} = F_{g20} = 20kg(9.81\,^{m}/_{s^2})$

$F_{N10} = 98.1N$ $\quad F_{N20} = 196.2N$

$\vec{F}_{f10} = -\mu F_{N10} = -0.15(98.1N)$ $\quad \vec{F}_{f20} = -\mu F_N = -0.15(196.2N)$

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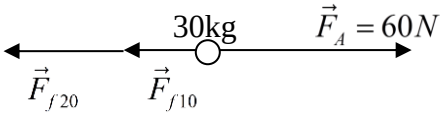
$\vec{F}_{f10} = -14.715N$ $\quad \vec{F}_{f20} = -29.43N$

Acceleration



$\vec{F}_{net} = \vec{F}_A + \vec{F}_{f10} + \vec{F}_{f20}$

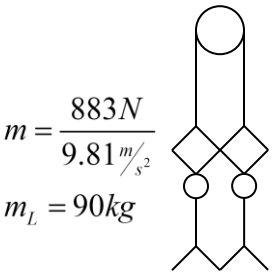
$\vec{F}_{net} = +60N + (-14.715N) + (-29.43N)$

$\vec{F}_{net} = +15.855N$

$\vec{a} = \frac{\vec{F}_{net}}{m} = \frac{+15.855N}{30kg}$

$\boxed{\vec{a} = +0.53\,^{m}/_{s^2}}$

8a)



$m = \dfrac{883N}{9.81\,^{m}/_{s^2}}$

$m_L = 90kg$

$m = \dfrac{932N}{9.81\,^{m}/_{s^2}}$

$m_C = 95kg$

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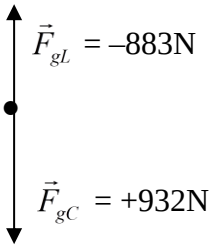
883N 932N



$\vec{F}_{gL} = -883\text{N}$

$\vec{F}_{gC} = +932\text{N}$

$\vec{F}_{net} = \vec{F}_{gC} + \vec{F}_{gL}$

$\vec{F}_{net} = +932N + (-883N)$

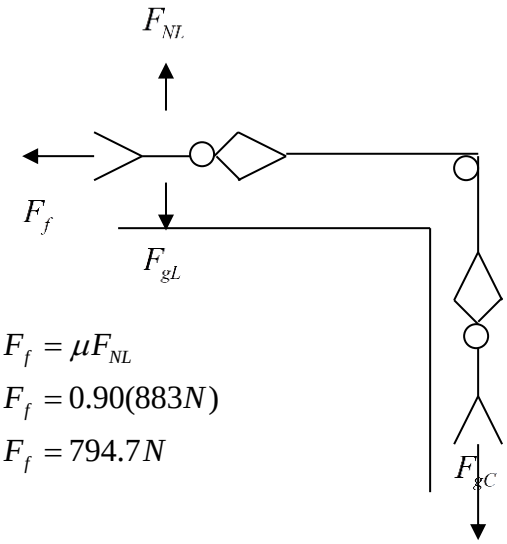
$\vec{F}_{net} = +49N$

$\vec{a} = \dfrac{Fnet}{m_T} = \dfrac{+49N}{95kg + 90kg}$

$\boxed{\vec{a} = +0.265\,^{m}/_{s^2}}$

b)

/5



$F_f = \mu F_{NL}$

$F_f = 0.90(883N)$

$F_f = 794.7N$

$\vec{F}_{net} = \vec{F}_{gC} + \vec{F}_f$

$F_{net} = +932N + (-794.7N)$

$F_{net} = +137.3N$

$\vec{a} = \dfrac{F_{net}}{m_T} = \dfrac{+137.3N}{(95kg + 90kg)}$

$\boxed{\vec{a} = +0.742\,^{m}/_{s^2}}$

c)

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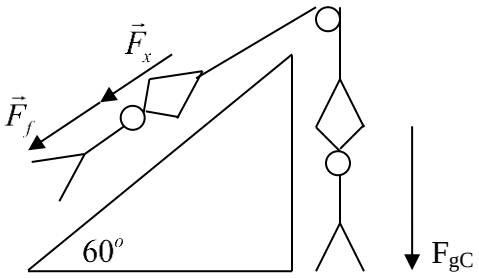

$F_{gLy} = \cos 60^{\circ}(883N)$

$F_{gLy} = 441.5N$

$F_{gLx} = \sin 60^{\circ}(883N)$

$F_{gLx} = 764.7N$

$F_f = \mu F_N$

$F_f = (0.40)(441.5N)$

$F_f = 176.6N$

$\vec{F}_{net} = \vec{F}_{gL_C} + \vec{F}_{gLx} + \vec{F}_f$

$\vec{F}_{net} = +932N + (-764.7N) + (-176.6N)$

$\vec{F}_{net} = -9.3N$

a negative net force indicates that the men do not move in the positive direction, therefore a = 0

Bonus 1)

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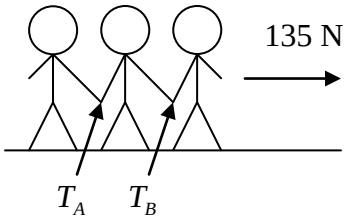
16 kg 24 kg 20 kg



a) $\vec{F}_{net} = +135$ (no fricton)

$$\vec{a} = \frac{\vec{F}_{net}}{m} = \frac{135N}{16kg + 24kg + 20kg}$$

$$\vec{a} = +2.25\,{}^{m}/_{s^2}$$

b) T_A may be calculated using the 16 kg girl

$$\vec{F}_{net} = m\vec{a}$$
$$\vec{T}_A = m\vec{a}$$
$$\vec{T}_A = 16kg(2.25\,{}^{m}/_{s^2})$$
$$\vec{T}_A = 36N$$

T_B may be calculated by combining the mass of the 16 kg girl and the 24 kg girl

$$\vec{F}_{net} = m\vec{a}$$
$$\vec{T}_B = m\vec{a}$$
$$\vec{T}_B = (16kg + 24kg)(2.25\,{}^{m}/_{s^2})$$
$$\vec{T}_B = 90N$$

Bonus 2)

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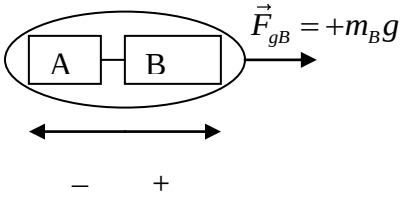

$$\vec{F}_{net} = m\vec{a}$$
$$\vec{F}_{gB} = (m_A + m_B)\vec{a}$$
$$+m_B g = (m_A + m_B)\vec{a}$$
$$+9.81\,{}^{m}/_{s^2}\, m_B = (170kg + m_B)(+2.5\,{}^{m}/_{s^2})$$
$$9.81m_B = 2.5(170) + 2.5m_B$$
$$7.31m_B = 2.5(170)$$
$$\boxed{m_B = 58.1kg}$$

Bonus 3)

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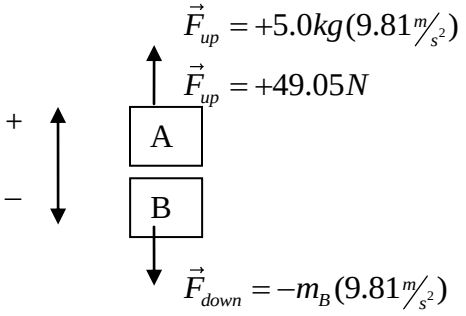
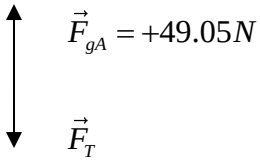
a) find mass B



$$\vec{F}_{net} = m\vec{a}$$
$$\vec{F}_{up} + \vec{F}_{down} = (m_A + m_B)\vec{a}$$
$$+49.05N + (-m_B g) = (5.0 + m_B)(-4.0\,{}^{m}/_{s^2})$$
$$49.05 - 9.81m_B = -20 - 4.0m_B$$
$$69.05 = 5.81m_B$$
$$\boxed{m_B = 11.9kg}$$

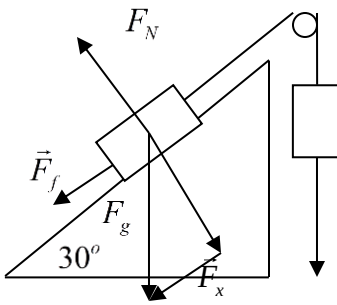
b) find tension – use mass A



$$\vec{F}_{net} = m\vec{a}$$
$$\vec{F}_{gA} + \vec{F}_T = m\vec{a}$$
$$+49.05 + \vec{F}_T = 5.0kg(-4.0\,{}^{m}/_{s^2})$$
$$\boxed{\vec{F}_T = -69.05N}$$

Bonus

4)



$\vec{F}_{g3} = +3.0kg(9.81\,^{m}/_{s^2})$

$\vec{F}_{g3} = +29.43N$

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$\vec{F}_x = -F_g \sin\theta$

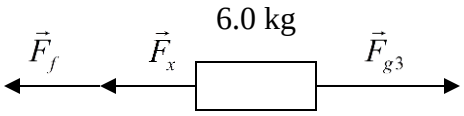
$\vec{F}_x = -29.43\sin(30)$

$\vec{F}_x = -14.715N$

$\vec{F}_f = -\mu F_N = -\mu F_g \cos\theta$

$\vec{F}_f = -0.20(29.43N)(\cos 30)$

$\vec{F}_f = -5.097N$



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

$\vec{F}_g + \vec{F}_f + \vec{F}_x = m\vec{a}$

$+29.43N + (-5.097N) + (-14.715N) = 6.0kg\vec{a}$

$9.62 = 6.0\vec{a}$

$\vec{a} = \dfrac{9.62}{6.0}$

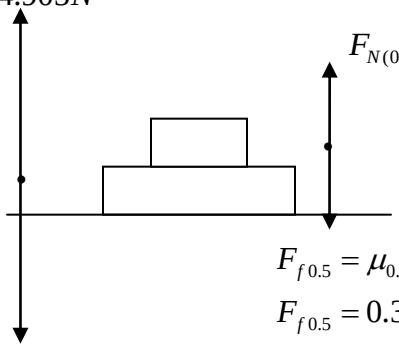
$\boxed{\vec{a} = 1.60\,^{m}/_{s^2}}$

Bonus

5)

$F_{N(1.0+0.5)} = 9.81N + 4.905N$

$F_{N(1.0+0.5)} = 14.715N$



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$F_{f(1.0+0.5)} = \mu_{(1.0+0.5)} F_{N(1.0+0.5)}$

$F_{f(1.0+0.5)} = 0.20(14.715)$

$F_{f(1.0+0.5)} = 2.94N$

$F_{f0.5} = \mu_{0.5} F_{N(0.5)}$

$F_{f0.5} = 0.35(4.905N)$

$F_{f0.5} = 1.72N$

The inertia of the 0.5 kg block will be overcome when the acceleration of the system exceeds the friction force between the two blocks.

$F_{f0.5} = ma$

$a = \dfrac{F_{f0.5}}{m}$

$a = \dfrac{1.72N}{0.5kg}$

$a = 3.43\,^{m}/_{s^2}$

Using the acceleration we can calculate the applied force.

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

$\vec{F}_A + \vec{F}_{f(1.0+0.5)} = m\vec{a}$

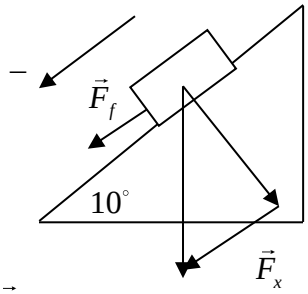
$\vec{F}_A = m\vec{a} - \vec{F}_{f(1.0+0.5)}$

$\vec{F}_A = 1.5kg(+3.43\,^{m}/_{s^2}) - (-2.94N)$

$\boxed{\vec{F}_A = +8.09N}$

Bonus

6)



$\vec{v}_i = +20\,m/s$

$\vec{v}_f = 0$

$\vec{a} = ?$

$\vec{d} = ?$

$\vec{F}_{net} = \vec{F}_f + \vec{F}_x$

$m\vec{a} = (-1.703m) + (-0.966m)$

$m\vec{a} = -2.669m$

$\vec{a} = -2.669\,m/s^2$

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$\vec{F}_x = F_g \sin\theta$

$\vec{F}_x = mg\sin(10)$

$\vec{F}_x = m(9.81\,m/s^2)\sin(10)$

$\vec{F}_x = 1.703m$

$\vec{F}_f = \mu F_N$

$\vec{F}_f = \mu F_g \cos\theta$

$\vec{F}_f = \mu mg\cos\theta$

$\vec{F}_f = 0.10(m)(9.81\,m/s^2)(\cos 10)$

$\vec{F}_f = 0.966m$

$\vec{v}_f^{\,2} = \vec{v}_i^{\,2} + 2\vec{a}\vec{d}$

$\vec{d} = \dfrac{\vec{v}_f^{\,2} - \vec{v}_i^{\,2}}{2\vec{a}}$

$\vec{d} = \dfrac{0 - (20\,m/s)^2}{2(-2.669\,m/s^2)}$

$\boxed{\vec{d} = +75\,m}$