\( m_A = 2m_B \) \\
\( F_A = F_B \) \\
\{ \quad a = \frac{F}{m} \Rightarrow A_A = \frac{1}{2} A_B \)

(a) In \( \Delta t \), the displacement \( \Delta S \) is
\[ \Delta S = \frac{1}{2} a \Delta t^2 \Rightarrow \Delta S \propto \Delta \]
\[ \therefore \Delta S_A = \frac{1}{2} \Delta S_B \]

 Block B goes twice as far as A

(b) To reach \( \Delta V \), the time needs is
\[ \Delta V = a \Delta t \]
\[ \Delta t = \frac{\Delta V}{a} \Rightarrow \Delta t \propto \frac{1}{a} \]
\[ \therefore \Delta t_A = 2\Delta t_B \]

 Block A takes twice longer than B

(c) To travel \( \Delta S \), the required time \( \Delta t \) is
\[ \Delta S = \frac{1}{2} a \Delta t^2 \]
\[ \Delta t = \sqrt{\frac{2\Delta S}{a}} \Rightarrow \Delta t \propto \frac{1}{\sqrt{a}} \]
\[ \therefore \Delta t_A = \sqrt{2} \Delta t_B \]

 Block A takes \( \sqrt{2} \) times longer than B
(d) After traveling distance $\Delta s$, the velocity is

$$\Delta v^2 = 2a \Delta s$$

$$\Delta v = \sqrt{2a \Delta s} \Rightarrow \Delta v \propto \sqrt{a}$$

$$\therefore \Delta u_A = \frac{1}{\sqrt{2}} \Delta u_B$$

**Block B goes $\sqrt{2}$ times faster than A**
To determine the scale reading, we don't need the properties of the spring because applying 10 N force is equal to adding a mass $10 N / 9.8 m/s^2 = 1.02 \text{ kg}$.

⇒ The total scale reading is $1 + 1.02 = 2.02 \text{ kg}$.
Right after the block being released, it will oscillate about the equilibrium position until finally stopped at that position.

Therefore, we don't have to know the properties of the spring but just observe the oscillation to find its equilibrium position which should be \( 1 \text{ kg} \) in this case.
3.

(a)

Net force is zero in vertical direction

\[ 2T \sin \theta - mg = 0 \Rightarrow T = \frac{mg}{2 \sin \theta} \]

(b)

Again the net vertical force is zero

\[ F_N - 2T \sin \theta = 0 \]

\[ \therefore F_N = 2T \sin \theta = 2 \left( \frac{mg}{2 \sin \theta} \right) \sin \theta = mg \]

If \( \theta < 30^\circ \)

\[ F_N = 2T \sin \theta < T \]

If \( \theta > 30^\circ \)

\[ F_N = 2T \sin \theta > T \]
Arranging as shown above, Jack can pull his jeep out of the mud by exerting force at the middle of the string. Because the maximum force Jack can apply is only 2000N, he can do in this way until

$$2T \sin \theta = F \Rightarrow 2 \times 5000 \times \sin \theta = 2000$$

$$\theta \approx 11.5^\circ$$

On reaching this limit, Jack can shorten the string and do it once again.
Define upward as "+"

Assuming the force between painter and platform is \( N \) and the acceleration of the whole system is \( a \).

(i) For the painter,

\[
\begin{align*}
\alpha & \uparrow \\
N & \uparrow \\
& \downarrow \text{m}_{\text{paint}} g \\
T + N - \text{m}_{\text{paint}} g &= \text{m}_{\text{paint}} a
\end{align*}
\]

(ii) For the platform

\[
\begin{align*}
\alpha & \uparrow \\
& \downarrow \text{m}_{\text{plat}} g \\
T - N - \text{m}_{\text{plat}} g &= \text{m}_{\text{plat}} a
\end{align*}
\]

\[
\begin{align*}
a &= \frac{2T - (\text{m}_{\text{paint}} + \text{m}_{\text{plat}}) g}{\text{m}_{\text{paint}} + \text{m}_{\text{plat}}} \\
N &= \frac{\text{m}_{\text{paint}} - \text{m}_{\text{plat}}}{2} \ (a + g)
\end{align*}
\]

To keep the painter on the platform, \( N \) must be positive. This is true if \( \text{m}_{\text{paint}} > \text{m}_{\text{plat}} \). \( a + g \) always \( \geq 0 \).
(a) To hold up the platform, \( a = 0 \)

\[
\Rightarrow a = \frac{2T - (M_{\text{paint}} + M_{\text{plat}})g}{M_{\text{paint}} + M_{\text{plat}}} = 0
\]

\[
T = \frac{M_{\text{paint}} + M_{\text{plat}}}{2} g
\]

(b) Since \( N \geq 0 \), the painter is always on the platform, the whole system will accelerate upward if \( a > 0 \). That is

\[
T > \frac{M_{\text{paint}} + M_{\text{plat}}}{2} g
\]

And there's no upper limit on acceleration.
To keep the block on the inclined plane, the vertical force must be zero.

\[ N \cos \theta = mg \]

\[ N = \frac{mg}{\cos \theta} \]

Therefore

\[ ma = N \sin \theta \Rightarrow a = \frac{N \sin \theta}{m} \]

\[ = \frac{mg \sin \theta}{m \cos \theta} \]

\[ = g \tan \theta \]

(b) If the friction is upward

Again, vertical force is zero

\[ N \cos \theta + NF \sin \theta = mg \]

\[ N = \frac{mg}{\cos \theta + ms \sin \theta} \]

Therefore

\[ ma = N \sin \theta - NF \cos \theta \Rightarrow a = \frac{\sin \theta - ms \cos \theta}{\cos \theta + ms \sin \theta} g \]
If the friction force is downward

Vertical force is zero

\[ N \cos \theta - mg - N \mu_s \sin \theta = 0 \quad \Rightarrow \quad N = \frac{mg}{\cos \theta - \mu_s \sin \theta} \]

Therefore

\[ ma = N \sin \theta + N \mu_s \cos \theta \quad \Rightarrow \quad a = \frac{\sin \theta + \mu_s \cos \theta}{\cos \theta - \mu_s \sin \theta} \]
Net force is zero in equilibrium

\[\begin{align*}
T - m_2 g &= 0 \\
2T - m_1 g &= 0
\end{align*}\]

\[m_1 = 2m_2\]

(b)

If the point A on string drops distance \(l\), the pulley will only drop \(\frac{1}{2}l\)

Therefore, \(\Delta x_{\text{string}} = 2\Delta x_{\text{pulley}}\) or \(A_{\text{string}} = 2A_{\text{pulley}}\)
From the argument above, we know that $a_1 = -\frac{1}{2} a_2$

For $m_1$ and $m_2$
\[
\begin{align*}
2T - m_1 g &= m_1 a_1 \\
T - m_2 g &= m_2 a_2 = -2m_2 a_1
\end{align*}
\]

\Rightarrow \quad a_1 = \frac{-m_1 + 2m_2}{m_1 + 4m_2} \quad \text{g}

\Rightarrow \quad a_2 = -2a_1 = \frac{2m_1 - 4m_2}{m_1 + 4m_2} \quad \text{g}