(1) \[ m = 0.8 \text{ kg} \]
\[ l_{\text{spring}} = 0.15 \text{ m} \]
\[ g = 10 \text{ m/s}^2 \]
\[ k = 2.5 \text{ N/m} \]

\[ F_{\text{spring}} = mg \]
\[ F_{\text{spring}} = kx \]
\[ X = \frac{mg}{k} \]

\[ l_{\text{spring}} + x = l_{\text{final}} \]
\[ l_{\text{final}} = l_{\text{spring}} + \frac{mg}{k} \]
\[ l_{\text{final}} = 0.15 \text{ m} + \frac{(0.8 \text{ kg})(10 \text{ m/s}^2)}{2.5 \text{ N/m}} \]
\[ l_{\text{final}} = 0.15 \text{ m} + 3.2 \text{ m} \]
\[ l_{\text{final}} = 3.35 \text{ m} \]

(2) \[ X = (3.2 \text{ m}) + (0.10 \text{ m}) = 3.30 \text{ m} \]

\[ F_x = \frac{1}{2} F_{\text{spring}} = 2.5 \text{ N/m}(3.30 \text{ m}) = 8.25 \text{ N} \]

\[ F_{\text{net}} = F_{\text{spring}} - mg = 8.25 \text{ N} - (0.8 \text{ kg})(10 \text{ m/s}^2) = 0.25 \text{ N} \]
UNIFORM CIRCULAR MOTION WITH $F_c = 10N$

$a_c = \frac{F_c}{m} = \frac{10N}{5kg} = 2 \text{ m/s}^2$

$a_c = \frac{V^2}{R}$

$V = \sqrt{Ra_c}$

$T = \frac{2\pi R}{V} = \frac{2\pi R}{\sqrt{Ra_c}}$

$T = \frac{2\pi R}{\sqrt{Ra_c}}$

$T = \frac{2\pi (2m)}{\sqrt{(2m)(2m)(18m/s)^2}} = 6.283 \text{ s} \ (D)$
(4) \( F_s = 10 \, N = k \times x \)  
\[x = \frac{F_s}{k} = \frac{10 \, N}{50 \, N/m} = 0.2 \, m\]

\[ R = L_0 + x \]  
\( L_0 \) = unstretched length of spring

\[ L_0 = R - x = 2.0 \, m - 0.2 \, m = 1.8 \, m \]  
(B)

(5) \[ PE = \frac{1}{2} k x^2 \]

\[ PE = \frac{1}{2} \left( \frac{50 \, N}{m} \right) (0.20 \, m)^2 = 1.0 \, J \]  
(A)

(6) \[ T - mg = ma_c = \frac{mv^2}{r} \]  
Newton's second law
(7) \[ T - mg = ma_c \]

\[ F_{net} = T - mg = ma_c \]

\[ F_{net} \uparrow \] (A)

(8) \[ KE_i + EPE_i + W_{nc} = KE_f + PE_f \]

\[ 0 + \frac{1}{2} kx^2 = \frac{1}{2} m v^2 + 0 \]

\[ kx^2 = mv^2 \]

\[ v^2 = \frac{k}{m} x^2 \]

\[ v = \sqrt{\frac{k}{m}} x = \omega x \]

\[ (v = \omega x) \]

Note: \[ v = \text{MAX Vel. for SHM} \]

\[ v(t) = \omega x \sin \omega t \]

\[ v_{\text{max}} \]
(8) continued

\[ \mathbf{v}_1 = \omega \mathbf{x}_1, \quad \mathbf{v}_2 = \omega \mathbf{x}_2 \]

\[ \frac{\mathbf{v}_2}{\mathbf{v}_1} = \frac{\omega \mathbf{x}_2}{\omega \mathbf{x}_1} = \frac{\mathbf{x}_2}{\mathbf{x}_1} \]

\[ \frac{\mathbf{v}_2}{\mathbf{v}_1} = \frac{\mathbf{x}_2}{\mathbf{x}_1} \quad \mathbf{x}_2 = 4 \mathbf{x}_1 \Rightarrow \]

\[ \frac{\mathbf{v}_2}{\mathbf{v}_1} = \frac{4 \mathbf{x}_1}{\mathbf{x}_1} = 4 \]

\[ \mathbf{v}_2 = 4 \mathbf{v}_1 \quad \text{(c)} \]

(9)

\[ \mathbf{K} E_i + \mathbf{E} P E_i + \mathbf{W}_{nc} = \mathbf{K} E_f + \mathbf{E} P E_f \]

\[ 0 + \frac{1}{2} \mathbf{R} \mathbf{x}^2 + 0 = \mathbf{K} E_f + 0 \]

\[ \mathbf{K} E_f = \frac{1}{2} \mathbf{R} \mathbf{x}^2 \quad \mathbf{R} \text{ and } \mathbf{x} \text{ are the same} \]

For both experiments \( \Rightarrow \) \( \mathbf{K} E_f \) is the same

For both \( \Rightarrow \) \( \mathbf{E}_1 = \mathbf{E}_2 \) (B)
Gravitational Potential Energy $\rightarrow$ Kinetic $\rightarrow$

Elastic Potential Energy

Potential $\rightarrow$ Kinetic $\rightarrow$ Potential

\[ KE_0 + GPE_0 + EPE_0 + W_{nc} = KE_f + GPE_f + EPE_f \]

\[ 0 + mgL + 0 + 0 = 0 + 0 + \frac{1}{2} kx^2 \]

\[ mgL = \frac{1}{2} kx^2 \]

\[ x = \sqrt{\frac{2mgL}{k}} \]

\[ m = 0.10 \, \text{kg} \]

\[ 2A = 0.30 \, \text{m} \]

\[ A = 0.15 \, \text{m} \]

\[ \frac{20 \text{ cycles}}{60 \, \text{s}} = 0.333 \text{ cycles/s} = 0.333 \, \text{Hz} = f \]

\[ T = \frac{1}{f} = \frac{1}{0.333 \, \text{Hz}} = 3 \, \text{s} \]
13) \( \frac{1}{f} = 0.333 \text{ Hz (A)} \)

14) \( \omega = \sqrt{\frac{k}{m}} \) Find \( k \) => \( \omega T = 2\pi \) \( \omega = \frac{2\pi}{T} \)

\[
=> \quad \frac{2\pi}{T} = \sqrt{\frac{k}{m}} \quad \left[ \frac{2\pi}{T} \right]^2 = \frac{k}{m}
\]

\[ k = m \left[ \frac{2\pi}{T} \right]^2 \]

\[ T = \frac{60 \text{ s}}{20 \text{ cycles}} \]

\[ \frac{1}{T} = \frac{20}{60} \]

\[ m = 0.10 \Rightarrow \]

\[ k = (0.10) \left[ \frac{2\pi \cdot 20}{60} \right]^2 \frac{N}{m} \quad (A) \]

15) \( \frac{0.30 \text{ m}}{2} \) "From one end of the oscillation to the other"

\[ 0.30 \text{ m} = 2A \]

\[ A = \frac{0.30 \text{ m}}{2} = 0.15 \text{ m (A)} \]
(16) \( w = \sqrt{\frac{k}{m}} \quad wt = 2\pi \quad f = \frac{1}{T} \Rightarrow \frac{w}{f} = 2\pi \)

\[
\frac{f_2}{f_1} = \frac{1}{2\pi} \sqrt{\frac{k_2 \cdot m_1}{k_1 \cdot m_2} \cdot 2\pi}
\]

\[
\frac{f_2}{f_1} = \sqrt{\frac{k_2 m_1}{k_1 m_2}} \quad m_1 = m_2 \\
\quad k_2 = 2k_1
\]

\[
\Rightarrow \quad \frac{f_2}{f_1} = \sqrt{\frac{2k_1}{k_1}} = \sqrt{2} \quad \{ f_2 = \sqrt{2} f_1 \}
\]

\[
\sqrt{2} \approx 1.414 = \Rightarrow \quad \frac{f_2}{f_1} \approx 1.41 f_1 \Rightarrow "41/2 \text{ increase}"
\]

\[\text{B}\]

(17) **Amplitude is set by initial conditions**, not by \( k \) or \( m \) \( \Rightarrow \text{Amplitude does not change} \)

\[\checkmark \text{ None of the above} \]

(18) **With no friction** energy flows from elastic potential energy to kinetic energy and back to elastic potential energy \( \text{(B)} \)
Velcro -> Stick together -> completely inelastic collision.

Consider:

I. Momentum is conserved
II. Kinetic ENERGY is conserved
III. The sum of kinetic and spring PE

(III) Which are true during collision

I. Momentum is conserved  True

II. Kinetic Energy conserved  False
   KE is not conserved in inelastic collisions

III. FALSE since KE is not conserved  (see III)

I ONLY IS TRUE (A)
(20) During oscillation

I. Momentum is not conserved in X direction for blocks because the external spring force acts on them.

II. KE is not conserved by itself. Energy is exchanged between kinetic and elastic potential energy.

III. Total energy is conserved. During oscillation, total energy = KE + EPE.

III only (B)

(21) Conserve momentum in X direction during collision.

\[ M_A v_A = (M_A + M_B) v_f \]

\[ v_A = \frac{(M_A + M_B)}{M_A} v_f = \left[ \frac{0.1 \text{ kg} + 0.4 \text{ kg}}{0.1 \text{ kg}} \right] (0.2 \text{ m/s}) = 1.0 \text{ m/s} \] (B)
(22) Conserve Mechanical Energy

\[ \text{INITIAL } KE = \text{FINAL } PE \]

\[ \frac{1}{2} (m_A + m_B) v_f^2 = \frac{1}{2} k A^2 \]

\[ A = \sqrt{\frac{(m_A + m_B)}{k}} v_f \]

\[ A = \sqrt{\frac{(0.1 \text{ kg} + 0.4 \text{ kg})}{50 \text{ N/m}}} \]

\[ = 0.2 \text{ m/s} \]

\[ = 2 \text{ cm} \]

(23) Acceleration greatest \(\Rightarrow\) Newton's Second Law \(\Rightarrow\)

\[ F = m a \]

\[ a = \frac{F}{m} \]

\(\Rightarrow\) Biggest \(a\) when \(F\) is maximum

\(F\) is largest when \(x = \pm A\) (spring is most stretched/compressed) \(\Rightarrow\) Largest and to right

\(\Rightarrow\) Spring must be \underline{stretched} \(\text{(extended)}\) \((A)\)
(24) ENERGY FLOW DURING COLLISION:

BEFORE: KE ONLY

AFTER: KE REMAINING IN BLOCKS + HEAT + SOUND

NO ELASTIC POTENTIAL ENERGY JUST AFTER COLLISION SINCE SPRING IS NOT YET COMPRESSED.

{KINETIC $\Rightarrow$ KINETIC + HEAT} (D)

(25) FOR THE "BLADE PATROLER" TO BE RESONATING WITH ANOTHER VIBRATION IN THE MACHINE:

I) THERE IS A WEAK COUPLING ("CONNECTION") TO ANOTHER VIBRATION. TRUE TO DRIVE RESONANCE ONLY A WEAK COUPLING IS NEEDED.

II) FALSE (SEE I)

III) THE TWO VIBRATIONS HAVE SIMILAR FREQUENCIES. TRUE RESONANCE OCCURS AT/NEAR A SPECIFIC FREQUENCY.