Conceptuals

C1 (circle one) A mass is seen to move in a straight line at constant velocity. Therefore, there are no forces acting on it.

TRUE  ( )  \[ F_2 \rightarrow F_1 \rightarrow V \]
\[ F_1 = F_2 \Rightarrow \text{const } V \]

C2 (circle one) Two bullets are fired simultaneously parallel to a horizontal plane. The bullets have different masses and different initial velocities. Which one will strike the plane first?

A) the fastest one
B) the slowest one
C) strike plane at same time.
D) the lightest one
E) the heaviest one

C3 A boy stands on a scale in an elevator. His feet are stuck to the scale by Velcro so the feet and the scale are always in contact (the Velcro by itself does not create new forces). The scale has springs in it so that when they are compressed, they push against the boy. Thus, when the elevator is sitting still on the surface of the Earth, the scale reads 500N for the 50Kg boy (for \( g \)\text{Earth}=10). We call a reading on the scale the boy’s “apparent weight.”

For any mass in gravity, we know \( \Delta y = \frac{1}{2} g \Delta t^2 \)

So \( \Delta t^2 = \frac{2h}{g} \Rightarrow \text{all masses have same } \Delta t \)

For each of the below, state whether the boy’s apparent weight will be more than 500N, less than 500N, zero, or insufficient info

1. the elevator is sitting still on the surface of the Moon (\( g_{\text{moon}} = \frac{1}{6} g_{\text{Earth}} \))

2. the elevator is accelerating up and away from the Earth but very far from the Earth surface in outer space

3. the elevator is accelerating up and away from the Earth but near the Earth surface

4. the elevator was hanging above the Earth and someone cut the cord so it is now plummeting to Earth - no air drag

\[ \begin{array}{|c|c|c|c|}
\hline
& 1. & 2. & 3. & 4. \\
\hline
< 500 & \text{insuff info} & > 500 & 0 \\
\hline
\end{array} \]

\( g \) smaller  \( g \rightarrow 0 \)
and \( a = ? \)
\( F_s = m(g+a) \)
\( a = -g \)
\( F_s = 0 \)
Two blocks are at rest on a frictionless incline, as shown in the figure. What are the tensions in the two strings if \( m_1 = 6.4 \) kg and \( m_2 = 4.2 \) kg?

\[ T_1 = \]

\[ T_2 = \]

\[ m_1 g \sin 20 = T_1 \]

\[ \Rightarrow T_1 = m_1 g \sin 20 \]

\[ T_1 = 21 N \]

\[ m_2 g \sin 20 + T_1 = T_2 \]

\[ T_2 = T_1 + m_2 g \sin 20 \]

\[ T_2 = (m_1 + m_2) g \sin 20 \]

\[ T_2 = 36 N \]
Problem 2

A 10 Kg wooden block sits on a 30 Kg wooden block with friction between them. The 30 Kg block is sitting on ice (no friction). A force of 120N is applied to the 10 Kg block, as shown.

1. Find the force of friction between the 2 blocks if there is no slippage between them.

   \[ F - f = 10a \]

2. Find the acceleration of the blocks.

   \[ F - 30a = 10a \]

   \[ F = 40a \]

   \[ a = \frac{F}{40} = 2 \text{ m/s}^2 \]

   So \[ f = 30a = 30 \times 2 = 60 \text{ N} \]
Three blocks, connecting ropes, and a light frictionless pulley comprise a system, as shown. An external force $P$ is applied downward on block $A$. The system accelerates at the rate of 2.5 m/s². The tension in the rope connecting block $B$ and block $C$ equals 60 N.

In the figure above, the external force $P$ is closest to:

A) 170 N
B) 190 N
C) 210 N
D) 230 N
E) 250 N

\[ P + 12g - T = 12a \]
\[ T - T_2 - 18g = 18a \]

Substitute $T$.
\[ P - 6g - T_2 = 30a = 75 \]
\[ P = 6g + T_2 + 75 \]
\[ P = 194 \text{N} \]
Problem 4

John is at the beach. He throws a light plastic ball with an initial speed of 2 m/s horizontally directly against the wind. The wind is blowing horizontally towards John and continually exerts a constant force $F = 0.02\text{N}$ pointing towards John. The wind is so strong that the force of gravity plays no role in the motion of the plastic ball. (The mass of the ball is 20 gm.)

1. How long does it take for the ball to come back to John from after it leaves his arm?

   45\text{s}

2. What is the maximum distance the ball gets away from John?

   2\text{m}

Paul now stands 2m away from John to his right and perpendicular to the wind. John now throws the plastic ball at an angle $\theta$ to the wind (with the same initial speed).

3. What angle must he choose so that the plastic ball exactly hits Paul?

   15^\circ

First 2 parts are 1-D.

2nd part is 2D — over
\[ a = \frac{0.02}{0.02} = 1 \text{ m/s}^2 \]

1. \( \Delta d = 0 \Rightarrow 0 = v_i \Delta t - \frac{1}{2} a \Delta t^2 \)
   \[ \Delta t = \frac{2v_i}{a} \Rightarrow \Delta t = 4s \]

2. \( \Delta d = d_{\text{max}} \) \( v_f = 0 \)
   So \( 0 = v_i^2 - 2a d_{\text{max}} \)
   \[ d_{\text{max}} = \frac{v_i^2}{2a} = 2m \]

3. Use 2-D const accel equations

\[ \Delta y = 0, \ v_x = \text{const} \]

\[ 0 = v_i \cos \theta \Delta t - \frac{1}{2} a \Delta t^2 \]
\[ \Delta t = \frac{2v_i \cos \theta}{a} \]

\[ \Delta x = v_x \Delta t \]
\[ 2 = v_i \sin \theta \Delta t \]

Substitute \[ \sin (2\theta) = \frac{2}{v_i^2} \]

\[ \theta = 15^\circ \]
A 2.0 kg wood block is launched up a wooden ramp that is inclined at a 35° angle. The block’s initial speed is 10 m/s. There is kinetic friction, \( \mu_k = 0.2 \). Static friction is not important here.

(a) What vertical height does the block reach above its starting point?

\[ 6.9 \text{ m} \]

(b) What speed does the block have when it slides back down to its starting point?

\[ 7.6 \text{ m/s} \]

(a) \( f \) is down, \( a \) is down
\[ f = \mu F_N \]
\[ F_N = mg \cos \theta \]
\[ a < 0 \quad ma = mgsin\theta + \mu mgcos\theta \]
\[ \frac{a}{g} = \sin \theta + \mu \cos \theta \]  
\[ a = \frac{a}{g} \]  
\[ a \text{ is down} \]
\[ a_+ = 7.0 \text{ m/s}^2 \]
\[ \Delta x = \frac{50}{a_+} = 6.9 \text{ m} \]

(b) \( f \) is up, \( a \) is down
\[ ma = mgsin\theta - \mu mgcos\theta \]
\[ \frac{a}{g} = \sin \theta - \mu \cos \theta \]  
\[ a_- = 4.0 \text{ m/s}^2 \]
\[ V_f^2 = 2a_+ \Delta x \]
\[ V_f^2 = 10^2 \frac{\alpha -}{a_+} \]
\[ V_f = 7.6 \text{ m/s} \]