I. Rifles are fired horizontally from platforms at various heights. The bullets fired from these rifles are identical, but they leave the rifle barrels at different speeds as shown in the diagrams. All of the bullets miss their targets and hit the ground. Ignore air resistance in this task.

![Diagram of different rifle shots with various speeds and trajectories]

a) Rank the motions based on the time it takes the bullet to hit the ground, from LONGEST TIME to SMALLEST TIME. **Explain your reasoning.**

TIME OF FLIGHT DEPENDS ON THE HEIGHT FROM WHICH THE BULLET IS SHOT ONLY. SO:

$$V_{0y} = 0, \Delta y = \frac{1}{2} a t^2 \Rightarrow t = \sqrt{\frac{2\Delta y}{g}}$$

$$B = C, D, A = E = F$$

b) Rank the motions based on the distance that the bullet lands from the tree, from LONGEST DISTANCE to SMALLEST DISTANCE. **Explain your reasoning.**

$$\Delta x = V_{0x} t = \left(\frac{V_{0x}}{g}\right) V_{0x} \Delta y \Rightarrow \Delta x \propto V_{0x} \sqrt{\Delta y}$$

A: $$(1200)(2) = 2400$$
B: $$(500)(18) = 9000$$
C: $$(800)(18) = 14400$$
D: $$(800)(46) = 36800$$
E: $$(1000)(2) = 2000$$
F: $$(800)(2) = 1600$$

$$A, C, E, D, F, B$$
II. A rope that runs over a frictionless tree limb has a 10 kg monkey holding on to one end and a 15 kg package attached to the other. They are both released from rest as shown at the right.

a) What is the magnitude and the direction of the monkey's acceleration after being released?

\[ M_p g - M_m g = (M_p + M_m) a \]

\[ a = \frac{(M_p - M_m) g}{M_p + M_m} = \frac{5}{25} g \]  

\[ a_{min} = \frac{g}{5} = 2 \text{ m/s}^2 \]  

direction = \text{UPWARD}

b) Find the tension in the rope while the monkey is accelerated.

\[ T - M_m g = M_m a \]

\[ T = M_m (g + a) \]

\[ T = 118 N \]

\[ T = 118 N \Rightarrow 120 N \]

c) Once the package is resting on the ground, the monkey starts to climb the rope. What is the magnitude of the least acceleration of the monkey must have if it is to lift the package off the ground?

\[ \text{IF THE TENSION = WEIGHT OF PACKAGE, THAT REPRESENTS THE MINIMUM ACCELERATION.} \]

\[ T - M_m g = M_m a \]

\[ a_{min} = \frac{4.9}{2} \text{ m/s}^2 \]
3. A gymnast weighing 500 N is suspended by two ropes from the ceiling as shown. The gymnast is at rest. The magnitude of the tension in the rope on the left is

a) greater than 250 N.
b) less than 250 N.
c) equal to 250 N.
d) cannot be determined.
e) none of the above

\[ 2T \sin \theta = 500 \text{ N} \]
\[ T \sin \theta = 250 \text{ N} \]
\[ T > 250 \text{ N} \]

4. A force \( P = 6.0 \text{ N} \) is applied to the block as shown. The magnitude of the block’s acceleration is 1.2 m/s\(^2\) to the right. What is the magnitude of the force of friction acting on the block?

- a. 2.2 N
- b. 2.4 N
- c. 2.8 N
- d. 2.9 N
- e. 3.6 N

\[ \sum F_x: P \cos 30^\circ - F_f = (2)(1, 2) \]
\[ F_f = (2 \text{ N}) \cos 30^\circ - (2)(1, 2) = 2.8 \text{ N} \]

5. If the only forces acting on a 2.0-kg ball are \( \vec{F}_1 = (2\hat{i} - 8\hat{j}) \text{ N} \) and \( F_2 = (5\hat{i} - 3\hat{j}) \text{ N} \)

what is the magnitude of the acceleration of the ball?

- a) 5.2 m/s\(^2\)
- b) 6.5 m/s\(^2\)
- c) 2.0 m/s\(^2\)
- d) 3.1 m/s\(^2\)
- e) 4.2 m/s\(^2\)

\[ \sum F_x = (2 + 5) = 7 \text{ N} \]
\[ \sum F_y = (-8 + -3) = -11 \text{ N} \]
\[ F_{\text{net}} = \sqrt{7^2 + 11^2} = 13 \text{ N} \]
\[ a = \frac{F_{\text{net}}}{m} = \frac{13 \text{ N}}{2 \text{ kg}} = 6.5 \text{ m/s}^2 \]
6. A mother and her child are next to each other on a carousel that is spinning around; both at the same distance from the center of the carousel. The mother’s mass is three times the mass of her child. Which of the following are the same for the mother and child:

a) speed and centripetal force

b) frictional force and acceleration

c) acceleration

d) speed and acceleration

e) centripetal force, speed, and acceleration

\[ \alpha = \frac{v^2}{r} \]

\[ \text{IS THE SAME} \]

\[ \text{IS THE SAME} \]

\[ \text{IS THE SAME} \]

BUT \( M_m \neq M_c \) SO NO FORCES ARE THE SAME

7. A roller coaster has a part with a vertical circular loop where, at its top, the car travels upside down. What must be true about the car’s speed so that the car and passenger don’t fall out? Assume that the wheels roll freely on the track.

a) \[ v_{\text{car}} \geq \sqrt{rg + a_c} \]

b) \[ v_{\text{car}} \geq \sqrt{rg} \]

c) \[ v_{\text{car}} = \sqrt{rg} \]

d) \[ v_{\text{car}} \geq \sqrt{rg - a_c} \]

e) \[ v_{\text{car}} = \sqrt{rg - a_c} \]

\[ F_{\text{net}} = \frac{MV^2}{R} \]

\[ F_{\text{net}} \geq mg \]

\[ \Rightarrow \frac{MV^2}{R} \geq mg \]

\[ \Rightarrow v \geq \sqrt{rg} \]

8. Three blocks are arranged with an inclined plane using a very light frictionless pulley as shown to the right. The coefficient of friction between the plane and the blocks is 0.300. Assume the rope is massless and doesn’t stretch. Find the tension, \( T \), in the rope connecting the hanging mass to the 5.00 kg mass.

a) 37 N

b) 110 N

c) 78 N

d) 94 N

e) 98 N

\[ F_{\text{fraction}} = (\mu \times 10 \text{ kg})g \cos \theta \]

\[ F_{\text{Earth on Blocks}} = 10 \text{ kg} \times g \times \sin \theta \]

\[ F_{\text{Earth on Surface}} \]

\[ \text{TAKE ENTIRE SYSTEM:} \]

\[ \sum F: \quad (10)g - \mu(10)g \cos \theta - (10)g \sin \theta \]

\[ \sum F = m_{\text{TOTAL}} \alpha \Rightarrow \alpha = \frac{10g (1 - \mu \cos \theta - \sin \theta)}{20} \]

\[ \Rightarrow T = 10 \text{ kg} \times 10 \text{ m/s}^2 \]

\[ \Rightarrow T = 87 \text{ N} \]