As a student at NJIT I will conduct myself in a professional manner and will comply with the provisions of the NJIT Academic Honor Code. I also understand that I must subscribe to the following pledge: On my honor, I pledge that I have not violated the provisions of the NJIT Academic Honor Code.

Please write your calculation at empty spaces. Your handwriting may help resolve any (if) doubts. Mark the closest answer on your scantron form.

**FORMULAS**

**Motions in two and three dimensions**

Position: \( x \mathbf{i} + y \mathbf{j} + z \mathbf{k} \)

Velocity: \( v_x = \frac{dx}{dt}, \quad v_y = \frac{dy}{dt}, \quad v_z = \frac{dz}{dt} \)

Projectile motion

- along the horizontal direction: \( x = x_0 + v_{0x} t \)
- along the vertical direction (\( a_y = -g = -9.8 \text{ m/s}^2 \), Positive y direction: upward)
  \[
  v_y = v_{0y} + a_y t, \quad y = y_0 + v_{0y} t + \frac{1}{2} a_y t^2, \quad v_y^2 - v_{0y}^2 = 2a_y(y - y_0)
  \]

Projectile motion from ground level to ground level:

\[
R = \frac{v_0^2}{g} \sin(2\theta), \quad y_{\text{max}} = \frac{v_0^2 \sin^2 \theta}{2g}
\]

**Force and Motion - I**

\( \vec{F}_{net} = m\vec{a} \) (Net force is the vector sum of all forces applied on an object of interest.)

SI unit for the force: 1 N (Newton) = 1 kg m/s²

\( g = 9.8 \text{ m/s}^2 \)

**Math**

\[
A = C \cos \theta, \quad B = C \sin \theta
\]

\[
C = \sqrt{A^2 + B^2}, \quad \theta = \tan^{-1} \left( \frac{B}{A} \right)
\]
#1. The coordinates of a bird’s position as a function of time \( t \) are given as

\[
x = 0.9t^2 - 2t + 5, \quad y = -0.2t^2 + 7t - 12, \quad z = 0.3t^2 + 4t + 1.
\]

\( x \) and \( y \) axes are in the horizontal plane, \( z \) axis points upward, \( x, y \) and \( z \) are in meters, and \( t \) is in second. Find the velocity of the bird at \( t = 2 \) second.

A. \( v_x = 2.6 \text{ m/s}, \ v_y = 3.4 \text{ m/s}, \ v_z = -1.7 \text{ m/s} \)

B. \( v_x = 1.6 \text{ m/s}, \ v_y = 6.2 \text{ m/s}, \ v_z = 5.2 \text{ m/s} \)

C. \( v_x = -2.0 \text{ m/s}, \ v_y = -7.0 \text{ m/s}, \ v_z = 4.0 \text{ m/s} \)

D. \( v_x = 2.8 \text{ m/s}, \ v_y = 4.4 \text{ m/s}, \ v_z = 0.8 \text{ m/s} \)

E. \( v_x = 0.9 \text{ m/s}, \ v_y = -0.2 \text{ m/s}, \ v_z = 0.3 \text{ m/s} \)

#2. A large watermelon is thrown from ground level at an angle of 30° above the horizontal at the speed of 2 m/s. Neglecting air resistance, the watermelon will travel what horizontal distance before striking the ground?

A. 0.35 m

B. 2.11 m

C. 1.52 m

D. 0.20 m

E. 3.54 m

#3. A heavy ball is suspended as shown. A quick jerk on the lower string will break that string but a slow pull on the lower string will break the upper string. The first result occurs because:

A. action and reaction is operating

B. air friction holds the ball back

C. the force is too large to move the ball

D. the ball is spherical

E. the ball has inertia
#4. When a certain force is applied to an object with a mass of 2 kg, its acceleration is 5.0 m/s². When the same force is applied to a different object, its acceleration is 4.0 m/s². The mass of the second object is:
   A. 10.0 kg
   B. 8.0 kg
   C. 5.0 kg
   D. 2.5 kg
   E. 1.25 kg

#5. Two forces are applied on an object. The first force has a magnitude of 20 N and points negative y axis. The second force has a magnitude of 5 N and points 30° counter-clockwise from the positive x axis. What is the net force? i and j are unit vectors pointing positive x and positive y directions, respectively.
   A. 5.0 N i − 20.0 N j
   B. −2.5 N i + 22.5 N j
   C. 2.3 N i − 15.5 N j
   D. 4.3 N i − 17.5 N j
   E. 2.5 N i + 15.7 N j

#6. Two forces are applied to a 5.0 kg box: one is 6.0 N to the north and the other is 8.0 N to the west. The magnitude of the acceleration of the box is:
   A. 1.2 m/s²
   B. 8.0 m/s²
   C. 2.0 m/s²
   D. 5.0 m/s²
   E. 3.6 m/s²

#7. A man whose mass is 70 kg is in an elevator. If the elevator is accelerating upward at 4.0 m/s², what is the force exerted on him by the elevator floor?
   A. 110 N
   B. 465 N
   C. 211 N
   D. 1210 N
   E. 966 N
#8. A pendulum bob with a mass $m$ is held at an angle $\theta$ from the vertical by a horizontal force $F$ as shown. The tension in the string supporting the pendulum bob is:

A. $mg / \cos \theta$
B. $mg / \sin \theta$
C. $mg \cos \theta$
D. $mg \sin \theta$
E. $mg$

#9. A block slides down a frictionless plane that makes an angle of $60^\circ$ with the horizontal. The magnitude of the acceleration of the block is:

A. 4.9 m/s$^2$
B. 9.8 m/s$^2$
C. 8.5 m/s$^2$
D. 19.6 m/s$^2$
E. 3.2 m/s$^2$

#10. A book rests on a table, exerting a downward force on the table. The reaction to this force is

A. the force of Earth on the book
B. the force of the table on the book
C. the force of Earth on the table
D. the force of the book on Earth
E. the inertia of the book

Workout problems in the next two pages.
Workout problems: Clearly show all your calculations

Workout problem #1.
A dart is thrown horizontally toward X at 20 m/s as shown. The dart hits Y. The horizontal distance between the initial position of the dart and the dart board is 5 m. Air resistance is negligible.

(a) Find the time that the dart takes to reach the dart board. [2 points]
(b) Find the distance between X and Y. [3 points]

More workout problem in the next page!
Workout problem #2
A 6 kg block and a 2 kg block are connected by a string as shown. The pulley has a negligible mass, and the surface is frictionless. [5 points]

(a) With the tension in the string represented by $T$, what is the net force on 2 kg block?
(b) With the tension in the string represented by $T$, what is the net horizontal force on 6 kg block?
(c) Apply Newton’s 2nd law on each block and find two equations with the tension $T$ and the magnitude of the acceleration of the blocks $a$.
(d) Find the magnitude of the acceleration $a$.
(e) Find the tension $T$. 

END