**Part 1:** 14 multiple choice questions, 1.5 points each.
Circle the letter of the most correct answer using a pen. Use $g = 10$ m/s$^2$.

Q1. Three physical quantities $(A, B, C)$ are related according to the equation $A = B/C^2$. The dimensions of B is $[L^2]$ and the dimensions of C is $[L]/[T]$. The dimensions of quantity A is:

a) $1/[T^2]$ b) $[T^2]$ c) $[L]/[T^2]$ d) $[T]/[L]$

Q2. Given the two vectors $\vec{A} = 2\hat{x} + 3\hat{y}$ and $\vec{B} = \hat{x} + 4\hat{y}$. What is the magnitude of the vector $\vec{C} = \vec{A} - 2\vec{B}$?

a) 5 b) $\sqrt{5}$ c) 4 d) 2

Q3. A car rounds a curve of radius 50 m at a constant speed of 20 m/s. The magnitude of the force acting on an 80 kg passenger inside the car is:

a) 800 N b) 0 N c) 640 N d) 400 N

Q4. A 5 kg object on a horizontal rough surface is subject to a constant horizontal force of 12 N such that the object moves with a constant velocity. What is the coefficient of kinetic friction between the object and the surface?

a) 0.56 b) 0.68 c) 0.24 d) 0.36

Q5. A particle moving with a velocity of $\vec{v}_0 = (5\hat{x} - 2\hat{y})$ m/s starts to accelerate with a constant acceleration of $\vec{a} = (3\ \hat{x})$ m/s$^2$ when its position is $(6\,\hat{y})$ m. Its position 2 seconds later is:

a) $10\hat{x} + 5\hat{y}$ b) $16\,\hat{x} + 2\hat{y}$ c) $16\,\hat{x} - 4\hat{y}$ d) $10\,\hat{x} - 2\hat{y}$

Q6. Two particles are positioned along the $x$-axis such that $m_1 = 8$ kg is located at 2 m and $m_2 = 2$ kg is located at $-1$ m. The position of the center of mass of the two objects is:

a) 1.8 m b) 1.4 m c) 1.2 m d) 1 m

Q7. On a highway, a car is struck in the rear by another car moving in the same direction. If the two cars stick together, their final kinetic energy just after the collision is:

a) less than the sum of the kinetic energies of the two cars before collision
b) greater than the sum of the kinetic energies of the two cars before collision
c) equal to the sum of the kinetic energies of the two cars before collision
d) anything is possible

Q8. An air cart of mass $2m$ with an initial speed of $v_0$ collides with another air cart of mass $m$ initially at rest. If the collision is elastic, the speed of the second cart just after the collision is:

a) $v_0$ b) $2v_0$ c) $0.67\ v_0$ d) $1.33\ v_0$

Q9. A 1 kg ball is dropped from rest a 20 m high building. If the energy lost due to air resistance is 8 J, what is the kinetic energy of the ball just before it hits the ground?

a) 192 J b) 208 J c) 200 J d) 416 J

Q10. A 2-kg ball with a velocity of $(4\,\hat{x})$ m/s hits a wall and bounces back with a velocity of $(-3\,\hat{x})$ m/s. The impulse exerted on the ball is (in kg.m/s):

a) $2\hat{x}$ b) $-2\hat{x}$ c) $-14\,\hat{x}$ d) $7\,\hat{x}$

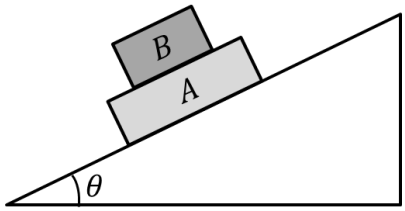
Q11. A 2 kg projectile is fired with initial velocity components of $v_{0x} = 30$ m/s and $v_{0y} = 40$ m/s. Neglecting air resistance, the kinetic energy of the projectile when it reaches its maximum height is

a) 0 J b) 2500 J c) 1600 J d) 900 J

Q12. Two ice skaters standing next to each other, initially at rest, push off against one another. The 40-kg skater acquires a velocity of 0.5 m/s to the right. What velocity does the 60-kg skater acquire?

a) 0.75 m/s b) 0.33 m/s c) 0.22 m/s d) 0.41 m/s

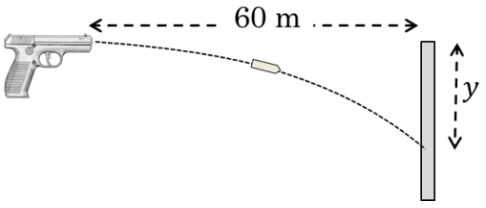
Q13. Two boxes are placed as shown in the figure. The magnitude of the normal force acting on box A is:




a) $(m_A + m_B)g\cos\theta$ b) $(m_A - m_B)g\cos\theta$

c) $m_A g\cos\theta$ d) $m_A g\cos\theta - m_B g\sin\theta$

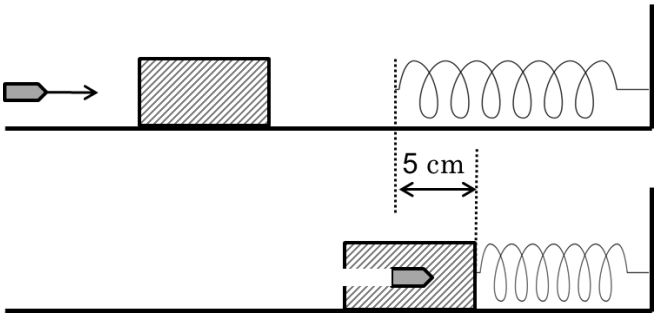
Q14. A gun is aimed horizontally at the top of a large target 60 m away. The initial speed of the bullet is 200 m/s. What is the distance from the top of the target to the point where the bullet strikes the target ($y$ in the figure)?



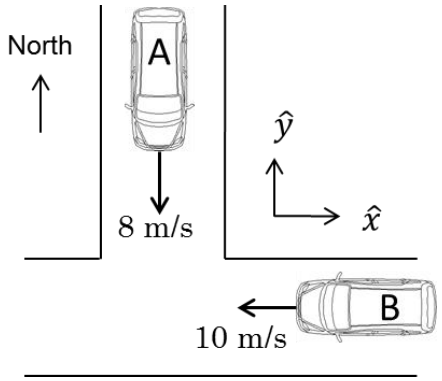

a) 1.3 m b) 1.5 m c) 0.3 m d) 0.45 m

**Part 2:** Solve the following three problems in the provided space.
**Show all your work** and include the appropriate units. Use $g = 10$ m/s$^2$.

Q1. (4 pints) A bullet of mass 0.01 kg moving horizontally strikes a block of wood of mass 1.99 kg initially at rest. The bullet embeds itself in the block. The block (with the bullet inside) then moves on a horizontal frictionless surface and compresses a spring with a spring constant of $k = 200$ N/m by 5 cm. Calculate the initial speed of the bullet. (4 points)



Q2. (3 points) At an intersection, a 1200 kg car moving at 8 m/s to the south (car A) collides with a 1400 kg car moving at 10 m/s to the west (car B). The two cars stick and move together after the collision. Assuming external forces can be ignored, calculate their velocity (magnitude and direction) just after the collision.



Q3. (4 points) A 60-kg skater enters a frictionless ramp. He reaches a maximum vertical height of 2 m on the ramp before coming to a stop.

a) Calculate his velocity on entering the ramp.
b) Assuming the ramp is inclined at 30° above the horizontal; calculate the distance he traveled on the ramp.
c) Calculate the work done by gravity.