Question 1: Version J

1. Two blocks, 1 and 2, slide toward each other on a horizontal surface. Block 1 has mass m and slides in the $+x$-direction with constant speed $2v_0$. Block 2 has mass $6m$ and slides in the $-x$-direction with constant speed v_0, as shown in Figure 1. The blocks then collide and stick together. The collision occurs from time $t = 0$ to $t = t_c$. After the collision, where $t > t_c$, the blocks move together with the same constant speed.

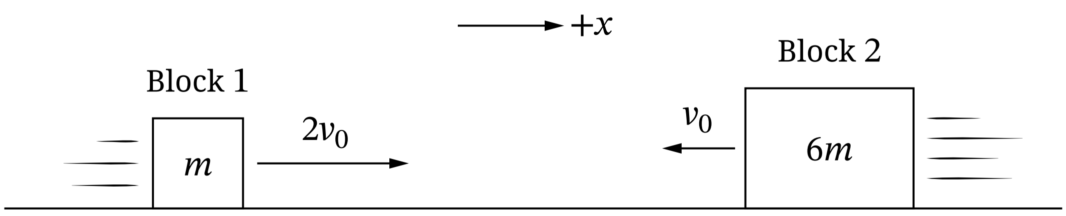

Figure 1

A. The diagrams in Figure 2 can be used to represent the momentum of blocks 1 and 2 before and after the collision. The momentum vector diagram for Block 1 before the collision is shown.

i. **Draw** arrows on the grids to represent the momentum vectors of Block 2 before the collision and the two-block system before and after the collision.

- Arrows should start at the zero-momentum line.
- The length of the arrows should be proportional to the relative magnitudes of the vectors.
- Represent an arrow of zero length by drawing a dot at zero.

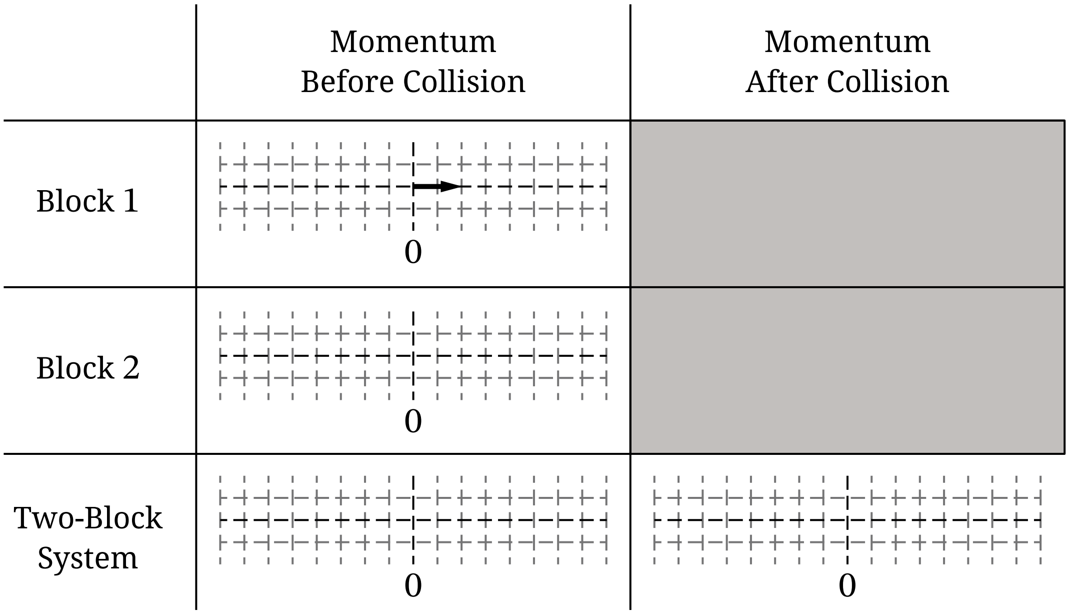

Figure 2

ii. During the time interval $0 \le t \le t_c$, a force F is exerted on Block 2 by Block 1 along the x-direction as a function of t that is modeled by $F(t) = F_{max}\sin(At)$, where A is a positive constant and F_{max} is the magnitude of the maximum force exerted on Block 2 by Block 1 during the collision.

Derive an expression for F_{max}. Express your answer in terms of m, v_0, A, t_c, and physical constants, as appropriate. Begin your derivation by writing a fundamental physics principle or an equation from the reference information.

B. Consider a new scenario where Block 1 initially slides in the $+x$-direction with a new constant speed v_1 and Block 2 again initially slides in the $-x$-direction with constant speed v_0. The blocks collide and stick together. In this new scenario, the two-block system has constant speed v_0 after the collision.

Derive an expression for v_1 in terms of v_0. Begin your derivation by writing a fundamental physics principle or an equation from the reference information.

Question 1: Mathematical Routines (MR) — 10 points

A	**(i)**	For drawing only one arrow for the momentum of Block 2 before the collision that points leftward and is 6 units long	**Point A1**
		For drawing only identical arrows for the momentum of the two-block system before and after the collision that are equal to the sum of the momentums drawn for blocks 1 and 2 before the collision	**Point A2**

Example Response

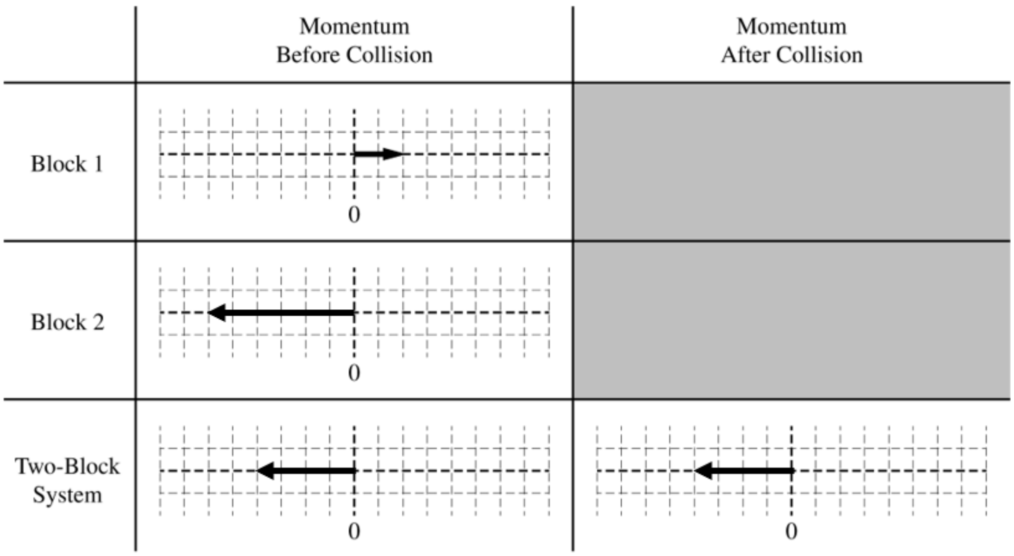

Figure 2

	(ii)	For a multistep derivation that includes the integral form of impulse or the differential form of Newton's second law	**Point A3**
		For indicating **one** of the following: • The final speed of Block 1 or Block 2 is $\frac{4}{7}v_0$. • The change in the momentum of Block 2 is $+\frac{18}{7}mv_0$. • The change in the momentum of Block 1 is $-\frac{18}{7}mv_0$. • The change in the velocity of Block 2 is $+\frac{3}{7}v_0$. • The change in the velocity of Block 1 is $-\frac{18}{7}v_0$.	**Point A4**
		For substituting the given expression for $F(t)$ into an expression for the impulse exerted on either block or the differential form of Newton's second law	**Point A5**
		For an integral with appropriate limits or a constant of integration	**Point A6**
		For a correct expression for F_{max} in terms of given quantities	**Point A7**