Q. 11.

Before	(Mass)	After
$10\vec{i}$	10	$p\vec{i}$
$-5\vec{i}$	50	$q\vec{i}$

$10(10) + 50(-5) = 10p + 50q$

$\Rightarrow p + 5q = -15$

$$\frac{p - q}{10 + 5} = -\frac{1}{2}$$

$\Rightarrow 2p - 2q = -15$

Solving these gives $p = -\frac{35}{4}$, $q = -\frac{5}{4}$.

The speeds are $8\frac{3}{4}$ m/s and $1\frac{1}{4}$ m/s.

$\vec{I_1} = M\vec{v} - M\vec{u}$

$= 10\left(-\frac{35}{4}\right) - 10(10)$

$= -187.5$ Ns

The magnitude of the impulse = 187.5 Ns

Q. 12. (a) (i) Newton's law of restitution: For two bodies impinging directly, their relative velocity after impact is equal to a constant (e) times their relative velocity before impact and in the opposite direction.

(ii) In a closed system the total momentum will be conserved.

(b) $v^2 = u^2 + 2as$

$\Rightarrow v^2 = 0^2 + 2(9.8)(19.6)$

$\Rightarrow v = 19.6$

Rebound speed $= (0.8)(19.6)$

$= 15.68$

$v^2 = u^2 + 2as$

$\Rightarrow 0^2 = (15.68)^2 + 2(-9.8)s$

$\Rightarrow s = 12.544$ m

(c) Gun Bullet Gun Bullet

$M_1u_1 + M_2u_2 = M_1v_1 + M_2v_2$

$\Rightarrow (2)(0) + (0.01)0 = (2)v_1 + (0.01)(300)$

$\Rightarrow v_1 = -1.5$ m/s

$\Rightarrow$ Initial speed of the gun = 1.5 m/s

To find acceleration:

$v^2 = u^2 + 2as = (0)^2$

$= (-1.5)^2 + 2a(0.05)$

$\Rightarrow a = -22.5$ m/s

$F = ma$

$\Rightarrow F = (2)(-22.5)$

$= -45$ N

A constant force of 45 N is required.

Q. 13. (i)

Before	(Mass)	After
$u\vec{i}$	M	$0\vec{i}$
$-v\vec{i}$	$3M$	$q\vec{i}$

$M(u) + 3M(-v) = M(0) + 3M(q)$

$$\Rightarrow q = \frac{u - 3v}{3}$$

$$\frac{0 - q}{u + v} = -e$$

$$\Rightarrow e = \frac{q}{u + v}$$

$$= \frac{u - 3v}{3u + 3v}$$ **QED**

(ii) $e \geqslant 0$

$$\therefore \frac{u - 3v}{3u + 3v} \geqslant 0$$

$\therefore u - 3v \geqslant 0$

$\therefore u \geqslant 3v$ **QED**

Q. 14.

Before	(Mass)	After
$5\vec{i}$	1	$p\vec{i}$
$\vec{i}$	2	$q\vec{i}$

$1(5) + 2(1) = 1(p) + 2(q)$

$\Rightarrow p + 2q = 7$

$\Rightarrow p = 7 - 2q$

$$\frac{p - q}{5 - 1} = -e$$

$\Rightarrow -4e = p - q$

$= (7 - 2q) - q$

$= 7 - 3q$

$$\therefore e = \frac{3q - 7}{4}$$

If there are to be no more collisions $v_B \leqslant v_C$

$\therefore q \leqslant 3$

If $q \leqslant 3$ then $e = \frac{3q - 7}{4} \leqslant \frac{3(3) - 7}{4} = \frac{1}{2}$

Answer: MAX Value $= \frac{1}{2}$