1. D Conservation of momentum would predict B as the answer. However, the total translational kinetic energy of the system decreases in that case. Therefore, the collision as stated is inelastic.

2. A According to the law of conservation of momentum the total linear momentum of a mechanical system remains constant. This quantity before she throws the ball equals zero, and therefore must equal that after. The equation to apply here is as follows:

$$m_1\boldsymbol{v}_{1i} + m_2\boldsymbol{v}_{2i} = m_1\boldsymbol{v}_{1f} + m_2\boldsymbol{v}_{2f}$$

3. D The translational momentumof an object is defined as the product of its mass and velocity:

$$\boldsymbol{p} = m\boldsymbol{v}$$

So its units are $\left[\mathrm{kg}\frac{\mathrm{m}}{\mathrm{s}}\right]$

A change in momentum is produced by an impulse:

$$\boldsymbol{I} = \boldsymbol{F}\Delta t = \Delta\boldsymbol{p}$$

A configuration of units equivalent to the one above is:

$$[\mathrm{N} \cdot \mathrm{s}]$$

4. B In an inelastic collision some portion of the translational kinetic energy is transformed into some other kind of energy, such as the energy of gamma radiation evolved in the collision.

5. A To see how Newton's third law, the law of action and reaction, predicts the conservation of momentum, imagine two objects in contact during a collision. According to the third law,

$$\boldsymbol{F}_{12} = -\boldsymbol{F}_{21}$$

the force exerted by object 1 upon object 2 is equal and opposite to the force exerted by 2 upon 1. These forces will each be in play for an equal amount of time, the duration of the collision, so the impulse exerted by each upon the other will also be equal. We know that an impulse equals a change in momentum:

$$\boldsymbol{I} = \boldsymbol{F}\Delta t = \Delta\boldsymbol{p}$$

Because the forces of action and reaction are equal and opposite, the changes in momentum they produce upon the respective objects will be so also. An increase of momentum in object 1 will be accompanied by an equal decrease in object 2, so the total remains constant.

With regard to C, Newton's first law, the law of inertia only speaks to the case of a single mass. It is true though that conservation of momentum implies that the center of mass of a system of objects will continue at constant velocity as long as the interactions are internal and not the product of outside forces. In fact conservation of momentum can be seen as a law of inertia for a system of masses.

6. A

7. D A is wrong because it is the center of mass of the system which moves with constant velocity. B is wrong because it is the magnitude of the two momenta which must be equal. C is true only if the center of mass is initially at rest (before firing).

8. C The -50 m/s corrects for gravity. The formulas were derived from conservation of momentum which is true if the system is not subject to outside forces.

9. C This answer is arrived at by substitution into the second equation. Remember (log 10 = 1). A facile application of conservation of momentum could lead to A, but remember that the velocity of the gases is relative to the rocket (perceived as if the rocket were at rest), so we have the gases expelled in an accelerating reference frame, while we perceive the velocity of the rocket itself with regard to its initial state of rest. (These differences disappear within the infinitesimal duration by which the calculus derives the second equation.)