2015 Dynamics Tutorial - Suggested Solutions

Self-Review Questions

Part 1: Newton's Laws, Inertia, Force, Momentum, Impulse

S1 D The mass is moving at a constant velocity, so it experiences zero net force.
For option C, note that the train cannot exert a force on the mass (they are not touching).
The only forces on the mass at any time are due to gravity and tension in the string.

S2 B Constant acceleration requires a constant net force (Newton's second law).

S3 C Net force is equal to the rate of change of momentum (Newton's second law).

S4 D A net force $F_{net} = 2F$ on a mass of 10 kg produces an acceleration of 60 m s^{-2}. Using Newton's second law in the form $F_{net} = m\,a$ yields that $F_{net} = 10 \times 60 = 600$ N. Hence, $F = F_{net} / 2 = 300$ N.
We next have that $F_{net} = 5F = 5 \times 300 = 1500$ N $= M \times (50$ m $s^{-2})$. Hence, $M = 1500 / 50 = 30$ kg.

S5 $u = 0$ and $v = 270$ km $h^{-1} = 270 / 3.6 = 75$ m s^{-1}. Hence, $\Delta v = v - u = 75$ m s^{-1}.
$\Delta p = m\,\Delta v = 20{,}000 \times 75 = 1{,}500{,}000$ kg m s^{-1} and $\Delta t = 2.0$ s.
$F_{avg} = \Delta p / \Delta t = 1{,}500{,}000 / 2.0 = 750{,}000$ N = **750 kN**.

S6 C $F_{avg} = \Delta p / \Delta t = 40 / 5 = 8$ N.
Hence, the impulse is $\Delta p = (8\text{ N}) \times (5\text{ s}) = 40$ N s.
The impulse is also equal to the area under the *F-t* graph. Hence,
$\Delta p = 40$ N s $= \frac{1}{2}(5 + 3)\,x = 4x \rightarrow x = 40 / 4 = 10$ N.

S7 E Whether or not one or both of the bodies are in equilibrium depends on the other forces that may be acting on them. Equilibrium of a given body is obtained when the net force due to all forces acting on *that* body is zero.

S8 C The two forces in an action-reaction pair must be of the same type.

Part 2: Conservation of Linear Momentum / Collisions

S9 D Linear momentum is always conserved in an isolated system if no net external force acts on the system. Kinetic energy is conserved only for elastic collisions. But total energy is conserved for all types of collisions (again for an isolated system).

S10 C Taking to the right as positive, the initial total linear momentum is 20 + (-12) = 8 N s.
By the principle of conservation of linear momentum, the final linear momentum is also 8 N s. Thus, $(-2) + p_Y' = 8$ N s $\rightarrow p_Y' = 8 + 2 = 10$ N s.