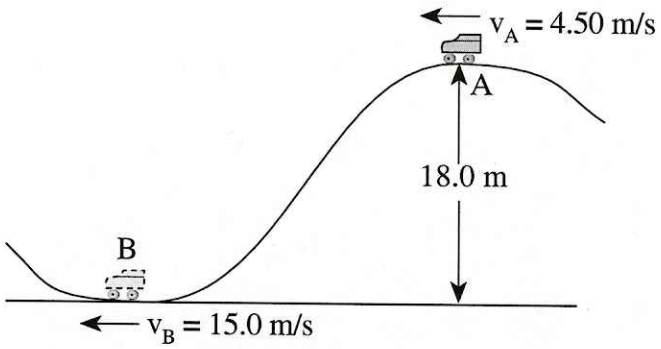
10. A 250 kg roller coaster car travels past points A and B with speeds shown in the diagram below. How much heat energy is produced between these points? **(7 marks)**



$E_A = E_B$

$E_{P_A} + E_{K_A} = E_{P_B} + E_{K_B} + E_h$ ← **2 marks**

$mgh_A + \frac{1}{2}mv_A^2 = mgh_B + \frac{1}{2}mv_B^2 + E_h$ ← **2 marks**

} **correct theory 4 marks**

$250\,\text{kg} \cdot 9.8\,\text{m/s}^2 \cdot 18\,\text{m} + \frac{1}{2} \cdot 250\,\text{kg} \cdot (4.5\ \text{m/s})^2 = 0 + \frac{1}{2} \cdot 250\,\text{kg} \cdot (15\ \text{m/s})^2 + E_h$ ← **1 mark**

$44\,100\ \text{J} + 2\,531\ \text{J} = 28\,125\ \text{J} + E_h$

$46\,631\ \text{J} = 28\,125\ \text{J} + E_h$

} **1 mark**

$\therefore E_h = \underline{1.85 \times 10^4\ \text{J}}$ $(18.5\ \text{kJ})$ ← **1 mark**

11. Two gliders having equal masses, each travelling along a level frictionless track at the same speed, approach each other head on. They stick together on impact and remain stationary at the point of impact. Does this situation mean that momentum has been lost during this particular collision? State your answer with supporting arguments which use principles of physics. **(4 marks)**

Conservation of momentum is a vector concept. As both of these gliders have the same mass and speed, the magnitude of their momentums is the same, but their directions are opposite. Thus one glider has a positive momentum, the other a negative. Therefore, the sum of the momentums before impact is ZERO. If momentum is conserved, then the sum of the momentums after the collision must also equal ZERO. After the collision, the two stationary gliders have a sum of ZERO momentum, and momentum has been conserved.

12. Two students throw identical tennis balls towards a building at the same speed. One ball strikes the wall, bouncing back at half its original speed. The other ball smashes a window and continues in the same direction at half its original speed. Did the two tennis balls experience the same impulse when in contact with the wall and the window? Justify your answer using principles of physics. **(4 marks)**

- The two tennis balls experienced **different** impulses. **1 mark**
- Impulse, or change in momentum, is a **vector** quantity. The ball which bounced from the wall sustained an impulse given by: $m\Delta v = m\left(-\frac{1}{2}v - v\right) = -\frac{3}{2}mv$. (The negative sign indicates the direction of the impulse.)
- The ball which smashed the window experienced an impulse given by: $m\Delta v = m\left(\frac{1}{2}v - v\right) = -\frac{1}{2}mv$.
- Therefore, the balls experienced different impulses. **3 marks**