Linear momentum. Collisions. Energy conservation

1. A bullet of mass m and speed v passes completely through a pendulum bob of mass M. The bullet emerges with a speed $v/2$. The pendulum bob is suspended by a stiff rod of length l and negligible mass. What is the minimum value of v such that the pendulum bob will barely swing through a complete vertical circle? See Fig.1.

2. Consider a frictionless track ABC as shown in Fig.2. A block of mass m_1 is released from A. It makes a head-on elastic collision with a block of mass m_2 at B, initially at rest. Calculate the maximum height to which m_1 rises after the collision.

3. During the battle of Gettysburg, the gunfire was so intense that several bullets collided in midair and fused together. Assume a 5 g Union musket ball moving to the right at 250 m/s, and 20^o above the horizontal, and a 3 g Confederate ball moving to the left at 280 m/s, and 15^o above the horizontal. Immediately after they fuse together, what is their velocity?

4. A billard ball moving at 5 m/s strikes a stationary ball of the same mass. After the collision, the first ball moves at 4.33 m/s at an angle of 30^o with respect to the original line of motion. Assuming an elastic collision (and ignoring friction and rotational motion), find the struck ball's velocity.

5. A particle of mass m, moving with speed v, collides obliquely with an identical particle initially at rest. Show that if the collision is elastic, the two particles move at 90^o from each other after collision. *Hint:* $(\mathbf{A}+\mathbf{B})^2 = A^2 + B^2 + 2AB\cos\theta$.

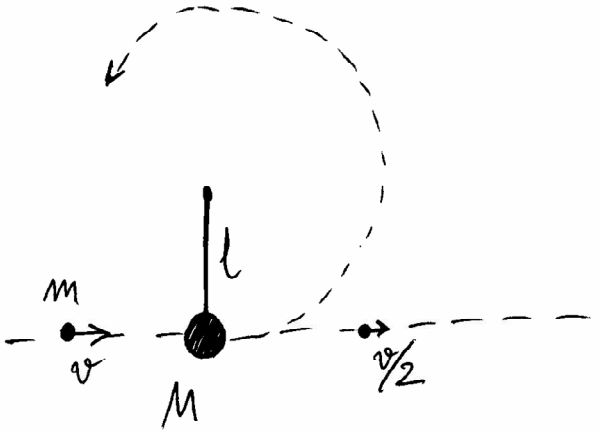


Fig. 1

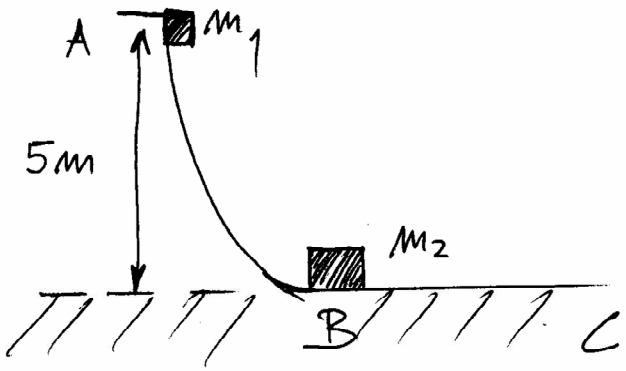
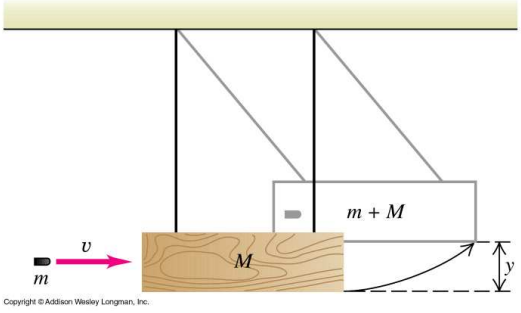


Fig. 2.

6. The figure shows a *ballistic pendulum*, a system for measuring the speed of a bullet. The bullet, with mass *m*, is fired into a block of wood with mass *M*, suspended like a pendulum, and makes a completely inelastic collision with it. After the impact of the bullet, the block swings up to the a maximum height *y*. Given the values of *y*, *m*, *M*, what is the initial speed of the bullet.



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7. A fisherman walks from one end of a boat to the other (from the boat's stern to the stem). What is the distance the boat will move? The mass of the man is *m* whereas the mass of the boat *M*. The length of the boat is *L*. Neglect all the outer forces (*Hint: the centre of mass of the system cannot be changed by the inner forces*).

8. A ball of mass *m* collides with a ball of mass *M* being initially at rest. The collision is central (head-on) and perfectly elastic. Find the velocities of the balls after the collision. Consider the special cases when a) $m >> M$, b) $m << M$, c) $m \approx M$.

9. A mass *M* hits a motionless mass *m*. The collision is completely inelastic and central (two masses stick together and begin to move). Calculate what part of the initial kinetic energy of the mass *M* is transferred into heat due to the collision. Consider also the cases when $M=m$ and $M=9m$.

10. A block of mass *m* sliding on a frictionless track hits another block of unknown mass being at rest. After the perfectly elastic collision two blocks begin to slide in the opposite directions but with the *same* speed. What is the mass of the block initially at rest?