Notes

Lec 8: Conservative Forces

1. Conservative Forces:
   1. The work done by conservative forces is irrelevant with the trajectory, only depending on the endpoints: such as gravity, and spring forces
   2. The change in mechanical energy is the work done by non-conservative forces
   3. 其他力做功机械能变化，内力（重力和系统内弹簧弹力）做功不改变机械能
2. Combination of springs
   - Series Configuration:two springs are connected end-to-end.

$$\frac{1}{k_{eq}} = \frac{1}{k_1} + \frac{1}{k_2}$$

   - Parallel Configuration: the two ends of each spring are connected to the mass and a fixed point, respectively.

$$k_{eq} = k_1 + k_2$$

3. **带钉子的问题 (Peg Problem)**:

- 钉子**不会**改变系统的总机械能。小球在撞上钉子前后瞬间，速度大小不变。
- 小球绕着钉子做圆周运动时，只是**圆周运动的半径 r 变了**。新的半径是绳长减去钉子所在位置的长度。
- 解题时，同样先用机械能守恒（比如从初始位置到绕着钉子转的最高点）求出速度，再用新的半径 r 列出向心力方程求拉力。例如，在小圆的最高点，拉力 T 和重力 mg 都向下，方程为 $T + mg = mv^2/r$

Lec 9: Work & Potential Energy

1. Potential energy of a planet
   1. Gravitational Potential Energy Formula

$$U = -\frac{GMm}{r}$$

   2. The gravitational potential energy is 0 at infinite faraway
2. Three velocities
   - First Cosmic Velocity (Orbital Velocity)

$$v_1 = \sqrt{\frac{GM}{r}}$$

- Second Cosmic Velocity (Escape Velocity)

$$v_2 = \sqrt{\frac{2GM}{r}}$$

Lec 10: Center of Mass

1. Conservation of the Center of Mass: Net external force is zero. Center of the mass remains at the same position
    1. First notice there is no external force
    2. Then find the CM
    3. CM coordinates do not change

A large guy with mass $2M$ and a smaller guy with mass M are holding onto a massless pole while standing on frictionless ice, as shown below. If the little guy pulls himself toward the big guy, where would they meet?

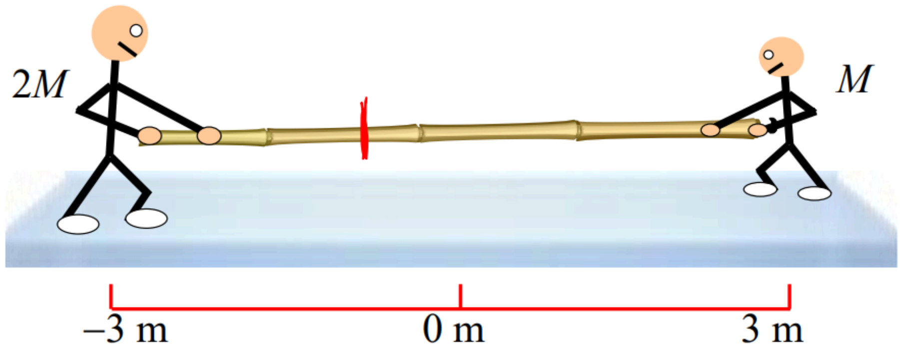
A) -3 m

B) $\boxed{-1 \text{ m}}$

C) 0 m

D) 1 m

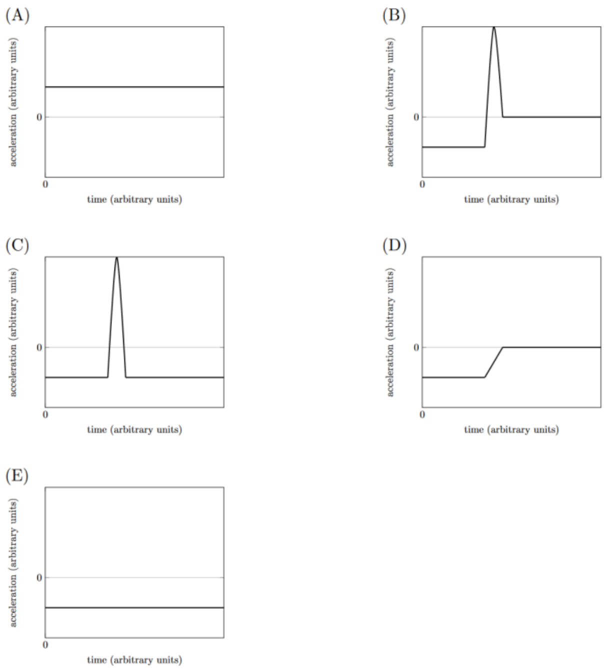
E) 3 m



$$X_{CM} = \frac{m_1 x_1 + m_2 x_2}{m_1 + m_2} = \frac{2M \cdot (-3\text{m}) + M \cdot (3\text{m})}{3M} = -1 \text{ m}$$

2. Focus on the complete motion(B)

   A large lump of clay is dropped off of a wall and lands on the ground. Which graph best represents the acceleration of the center of mass of the clay as a function of time?



3. The velocity of the cm has the same calculation method of cm

Lec 11: Conservation of Momentum

1. Trick in solving 2 equations of momentum conservation and energy conservation

$$V_f = 2V_{same} - V_{initial}$$

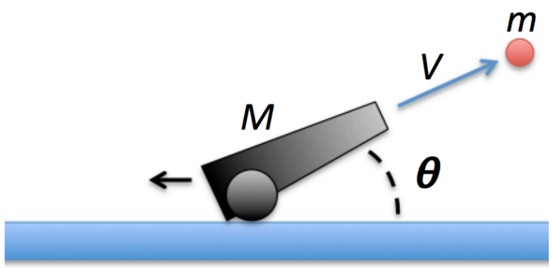
2. 2D 碰撞问题
   - 正交分解, 把所有动量分解到 x 和 y 两个方向上，两个方向的动量**分别守恒**
3. 除非题目是在讨论天体运动，否则就把“重力”当作一个来自地球的、作用在你研究的物体上的“外力”。

Lec 12: Elastic Collisions

1. CM framework: velocity of the CM, i.e. V_{same} We know that $V_f = 2V_{same} - V_{initial}$, so the velocity in the CM framework is $V_{same} - V_f$
2. In a completely elastic collision, the magnitudes of the relative velocities of the two carts after the collision are equal to those before the collision, but in opposite directions.

Lec 13: Impulse and Reference Frames

A cannon of mass M = 2100 kg is initially at rest on a horizontal frictionless surface of ice. It fires a cannonball of mass m = 55 kg (not included in M). An observer on the ice measures the initial angle of the cannonball as it exits the cannon's barrel to be θ = 25 degrees above horizontal, and its initial speed to be V = 290 m/s. The cannon recoils and slides to the left.



2) In the reference frame of the cannon, the initial angle of the cannonball relative to the surface of the ice is

- (●) less than 25 degrees.
- ( ) equal to 25 degrees.
- ( ) greater than 25 degrees.

在大炮参考系中，炮弹的水平速度分量更大，而垂直分量不变，使得角度更小，因此答案是：

在大炮参考系中，炮弹的水平速度分量更大，而垂直分量不变，使得角度更小