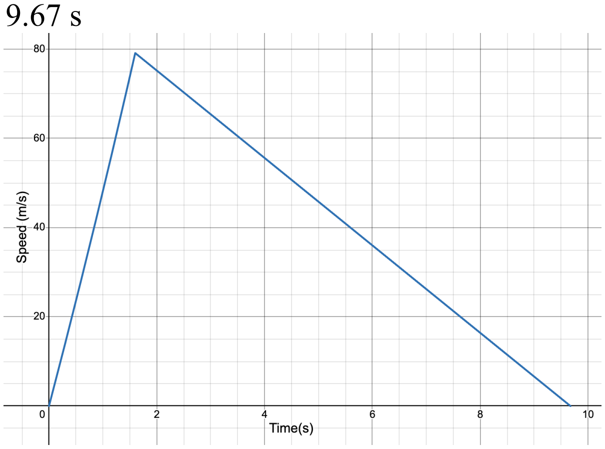
AP Physics C: Mechanics – Momentum Assignment

1. a. $x_{CM} = 3.8$ m
   b. $x = -6.8$ m
2. 4670 km from center of Earth
3. 1.26 m from big kid
4. a. 1010 g
   b. 1.32 m from the tail
5.
6. $y_{CM} = h\dfrac{b_1 + 2b_2}{3(b_1 + b_2)}$
7. $x = \dfrac{hw^2 - 2\pi R^2 c}{2hw - 2\pi R^2}, \quad y = \dfrac{h}{2}$
8. a. 0.400 m from large cart
   b. 2.00 m/s^2 in dir. of force
   c. 16.0 m, 8.00 m/s in dir. of force
   d. large cart: 15.8 m
      small cart: 16.3 m
9. 83.3 m
10. a. 0.375 m/s opp. dir. of walk
    b. 1.5 m opp. dir. of walk
    c. 0
    d. The speed of the boat relative to shore while the gondolier moves would be greater than before in order that the center of mass can remain at rest with zero velocity. However, the amount that the boat moves should be the same as before again so that the center of mass remains in place.
    e. If drag on the boat is significant, then there is a net external force in the opposite direction that the boat moves. This external force is in the *same* direction that the gondolier is walking, so the center of mass will accelerate in that direction and *not* remain at rest. Once the gondolier stops walking the boat will have moved less backward, and both the gondolier and the boat should have a velocity in the direction that he walked (*i.e.* the system will not be at rest).
11. 11.2 m
12. a. 1.47 m/s, right
    b. 1.05 m, right
13. a. 5.00 kg m/s, 0.0°
    b. 1.50 kg m/s
    c. 4.00 m/s
    d. 4.00 kg m/s, 0.0°, 1.50 kg m/s,
       2.00 m/s
14. a. 13.0 m/s
    b. 14.0 m/s
    c. 11.2 m/s
15. 3.42 m/s, opp. dir.
16. 10$\underline{0}$ m/s, right (unlikely!)

17. a. 7.35 m/s, 109.6°
    b. 478 kg m/s, 109.6°
    c. 19.8 m/s, 110.0°,
       1290 kg m/s, 110.0°
18. 462 m/s
19. 1.19 m
20. 0.233 m
21. smaller: 0.286 m/s
    larger: 0.107 m/s, opp. dir.
22. If there is no friction between the chair and the floor then there is no way the boy can move the chair across the room, because there would be no net external force in a horizontal direction acting on the boy-chair system and its center of mass would not accelerate horizontally. However, because there obviously **will** be friction, it **is** possible to move the chair. The boy can shift his weight to change the location of the center of mass relative to the chair, in which case the chair would slide without friction. Friction opposes the sliding of the chair, which sets the system's center of mass into motion. (Try doing this yourself!)
23. a. The force of the brake pad acting on the rim of the wheel is internal if the rider and the bicycle are defined as the system. Any time an object in the system exerts a force on another object in the system it is said to be an internal force.
    b. The force of the road acting on the tires of the bike (friction!) is an external force that stops the bike. The internal force of the brakes *would* cause the wheels to rotate slower, but if that happened then the tires would start skidding on the road. Friction with the road opposes this skidding and becomes the external force that slows the bike.
    c. Define the system to include the Earth as a whole and then it can be correctly claimed that any momentum lost by the bike and rider must be gained by the Earth!
24. 100%, elastic; 57%, inelastic
25. larger: 1.00 m/s, 0.0°
    smaller: 4.00 m/s, 180.0°
26. a.
    b. The missing kinetic energy transforms into mainly heat (and maybe a little sound) when the clay sticks to the block.
27. 7 m/s, left; $m_A/m_B = 3/11$
28. a. 1.93×10^5 m/s
    b. 2.55×10^4 m/s, 288.6°
29. a. 17.3 m/s
    b. slower: 120.0°; faster: 210.0°
       (or 240.0° and 150.0°)
30. a. 24.9 m/s, 0.0°
    b. 5.08 m/s, 0.0° (club)
       24.9 m/s, 180.0° (ball)
    c. 19.8 m/s, 0.0° (club)
       49.8 m/s, 0.0° (ball)
31. a. 5.27 kg m/s, 0.0°
    b. 0.00916 s
32. a. 11.9 kg m/s, 17.7°
    b. 5960 N, 17.7°

33. a. 42000 kg m/s
    b. 130 h
34. a. 0.049 N
    b. 2.9×10^6 Ns
35. a. 3040 m/s
    b. 1.4×10^9 Ns
36. a. −3 N
    b. −1 N
    c. −2.7 Ns
37. a. 0.0109 s
    b. 957 N
    c. 6.98 Ns, down
    d. 0.0590 Ns, down
    e. 6.92 kg m/s, up
38. The bounce will be essentially a normal force acting on the ball. Therefore the impulse on the ball is perpendicular to the surface and the change in momentum will also be perpendicular to the surface. Without a force parallel to the surface, the parallel component of the ball's momentum is unchanged and so too the parallel component of the ball's velocity. Assuming an elastic collision, the perpendicular component of the speed of the ball must remain the same. Because the parallel and perpendicular components of the velocity have the same magnitudes as before the bounce, the angle with the surface is the same after as it was before.
39. a. 28.0 km/s
    b. 12.1 km/s
    c. 7.52×10^{-5} m/s^2 (fully laden)
       1.16×10^{-4} m/s^2 (nearly empty)
40. a. 79.1 m/s
    b. 9.67 s
    c. 

    d. 383 m (estimate), 381 m (explicit)