2007 $F = ma$ Answers to Selected Problems
Gunn Physics Club
Wednesday, October 7, 2015

1. E
2. B
3. B
4. C
5. A
6. B
7. D
8. B
9. D

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1. The object crosses the x-axis when the y-coordinate is 0, or when $2t - 5 = 0$. The answer is $\boxed{\textbf{(E)}\ 2.5\ \text{s}}$.

2. From the region [30, 90], the graph looks fairly linear, so the first derivative will be a constant. This constant is around $\frac{20-10}{90-60} = \frac{1}{3} \approx 0.33 \implies \boxed{\textbf{(B)}\ 0.33\ \text{m/s}^2}$.

3. $v_{avg} = \dfrac{\Delta x}{\Delta t} = \dfrac{(8(2) - 3(2)^2) - (8(1) - 3(1)^2)}{1} = \boxed{\textbf{(B)}\ -1\ \text{m/s}}$.

4. We have that $v_0 = 0$, $a = g$, and the equation

$$d = v_0 t + \frac{1}{2} g t^2 \Rightarrow d = \frac{1}{2} g t^2.$$

   If we consider the first section of travel, we have

$$h = \frac{g}{2} \cdot (1\,\text{s})^2.$$

   If we consider the first two seconds of travel, t doubles, so h is multiplied by 4. So the distance traveled in the first 2 seconds of freefall is $4h$, and our answer is $4h - h = \boxed{\textbf{(C)}\ 3h}$.

5. After drawing a free-body diagram for the crate, it becomes clear that the only forces on it are gravity, the normal force from the sleigh on the crate, and static friction from the sleigh on the crate. Out of these three, the only force that is in the direction of the acceleration is the friction, so the answer is $\boxed{\textbf{(A)}\ \text{the force of static friction of the sleigh on the crate}}$.

6. The displacement x is the integral of the velocity v with respect to time, or $x = \displaystyle\int_0^t 5t'^2\ dt' = \boxed{\textbf{(B)}\ \frac{5t^3}{3}}$.

7. The first transfer is $\frac{1}{2}m(2^2 - 0^2) = \frac{m}{2}(4)$. The second is $\frac{1}{2}m(4^2 - 2^2) = \frac{m}{2}(12)$.

   The answer is hence $\boxed{\textbf{(D)}\ \text{three times the amount}}$.

8. The potential energy is inversely proportional to the distance between the two stars. Thus, when the distance is double, the potential energy will get halved; i.e. $U \to \boxed{\textbf{(B)}\ U/2}$.

9. Draw a free-body diagram for the entire block–wedge system. The only two forces are gravity pointing down, and a normal force pointing up. There is no frictional force as the wedge is on a frictionless surface. Because the block is moving down, the center of mass must be decreasing vertically, so the answer is $\boxed{\textbf{(D)}\ \text{moves vertically with increasing speed}}$.