HW #3 (Kinematics Problems) Answers

Multiple Choice: For each question below, choose the right answer and give a short explanation as to why it is right.

1. An object is released from rest on a planet that has no atmosphere. The object falls freely for 3.0 meters in the first second. What is the magnitude of the acceleration due to gravity on the planet?
(A) 1.5 m s^2 (B) 3.0 m/s^2 **(C) 6.0 m/s^2** (D) 10.0 m/s^2 (E) 12.0 m/s^2

Explanation:
$y=y_0 + v_{y0}t + ½ gt^2$ solving for $g= (y-y^0-v_{y0}t)2/t^2 = (3m-0m-0m/s)2/1s^2 = 6m/s^2$

2. In the absence of air friction, an object dropped near the surface of the Earth experiences a constant acceleration of about 9.8 m/s^2. This means that the…..
(A) speed of the object increases 9.8 m/s during each second
(B) speed of the object as it falls is 9.8 m/s
(C) object falls 9.8 meters during each second
(D) object falls 9.8 meters during the first second only
(E) rate of change of the distance with respect to time for the object equals 9.8 m/s^2

Explanation:

From the definition of acceleration, an acceleration describes the rate of change of an object's velocity.

3. A 500-kilogram sports car accelerates uniformly from rest, reaching a speed of 30 meters per second in 6 seconds. During the 6 seconds, the car has traveled a distance of
(A) 15 m (B) 30 m (C) 60 m **(D) 90 m** (E) 180 m

Explanation:
$v=v_0+at$ solving for $a=(v-v_0)/t = (30m/s-0m/s)/6s = 5m/s/s$
$x= x_0 + v_0t + ½ at^2$ solving for $x = 0m + 0m/s + ½ (5m/s/s) (6m/s/s)^2 = 90$ m

<u>Free Response:</u>

<u>Directions:</u> Answer each question below, showing all necessary work.

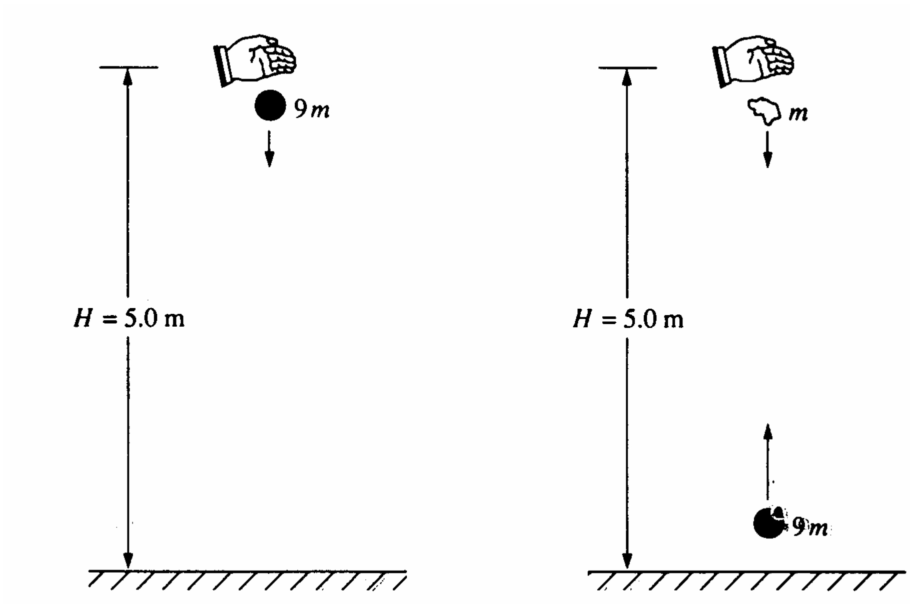
The first meters of a 100-meter dash are covered in 2 seconds by a sprinter who starts from rest and accelerates with a constant acceleration. The remaining 90 meters are run with the same velocity the sprinter had after 2 seconds.

a. Determine the sprinter's constant acceleration during the first 2 seconds.
$x = x_0 + v_0t + ½ at^2$ so, $10m = 0m + 0m/s(2s) + ½ a(2s)^2$
solving for $a = 20m/4s^2$ = **5m/s/s**

b. Determine the sprinters velocity after 2 seconds have elapsed.
$v=v_0 +at$ so, $v = 0m/s + 5m/s/s (2s)$ = **10m/s**

c. Determine the total time needed to run the full 100 meters.
Time for last 90 meters = distance / speed so, 90m/10m/s = 9s
Total time for full 100 meters = **11s**

Free Response:



A ball of mass 9m is dropped from rest from a height H = 5.0 meters above the ground, as shown above on the left. It undergoes a perfectly elastic collision with the ground and rebounds. At the instant that the ball rebounds, a small blob of clay of mass m is released from rest from the original height H, directly above the ball, as shown above on the right. The clay blob, which is descending, eventually collides with the ball, which is ascending. Assume that g = 10 m/s^2, that air resistance is negligible, and that the collision process takes negligible time.

a. Determine the speed of the ball immediately before it hits the ground.

$v_y^2 = v_{yo}^2 + 2ay$

$= (0\text{m/s})^2 + 2(10\text{m/s}^2)(5.0\text{m})$

$= 100\text{m}^2/\text{s}^2$

v_y = 10m/s

b. Determine the time after the release of the clay blob at which the collision takes place.

The ball will be traveling up before the collision, while the clay will be traveling down. The ball will start its upward motion with a speed of 10m/s and the clay will start its downward motion from rest. Both will accelerate downward at 10m/s/s. Knowing that they will collide when they both reach the same vertical position, you must determine the time that both will occupy the same vertical position. This can be done by setting two separate equations for position equal to each other and solving for time.

$y_0 + v_{yo}t + ½ at^2 = y_0 + v_{yo}t + ½ at^2$

$-5\text{m}+10\text{m/s}\ (t) + ½\ 10\text{m/s/s}\ (t)^2 = 0\text{m} + 0\text{m/s}\ (t) + ½\ 10\text{m/s/s}\ (t)^2$

$-5\text{m} + 10\text{m/s}(t) + 5\text{m/s/s}(t)^2 = 5\text{m/s/s}(t)^2$

$-5\text{m} + 10\ \text{m/s}(t) = 0$

$10\text{m/s}(t) = 5\text{m}$

$(t) = 5\text{m}/10\text{m/s} =$ **0.5 sec**

c. Determine the height above the ground at which the collision takes place.

$y= y_0 + v_{yo}t + ½ at^2$ so, $y = 0\text{m} + 10\text{m/s}(0.5\text{s}) + ½ (-10\text{m/s}^2)(0.5\text{s})^2$ = **3.75m**

solving for ball moving up from ground level.

d. Determine the speeds of the ball and the clay blob immediately before the collision.

Ball: $v_y= v_{yo} + at$ so, $v_y = 10\text{m/s} + -10\text{m/s/s}(.5\text{sec})$ = **5m/s**

Clay: $v_y= v_{yo} + at$ so, $v_y = 0\text{m/s} + -10\text{m/s/s}(.5\text{sec})$ = **-5m/s**