Arts & Science 2D06

Quiz #1 2019 Sept 19 **Name:** Solutions

NB: Mark values are given in brackets [ ] beside each problem. Write all your answers on the quiz paper. No books or notes allowed. Time to write quiz: 50 minutes.

Solution for quadratic equation: $x = (-b \pm \sqrt{b^2 - 4ac})/2a$

Constant velocity: $x = x_0 + vt$

Uniform acceleration: $x = x_0 + v_0 t + \frac{1}{2}at^2$ $v^2 = v_0^2 + 2a(x - x_0)$ $v = v_0 + at$

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1. [3] In general, in projectile motion (*i.e.*, motion in 2 dimensions), the horizontal component of a projectile's velocity:

(An explanation is not required, but you can provide one if you would like; ignore air resistance)

(a) is zero.

→ (b) remains a non-zero constant.

(c) continuously increases.

(d) continuously decreases.

(e) any of the above, depending on its position.

The acceleration due to gravity affects only the projectile's motion in the y-direction.

If air resistance is ignored, then nothing is affecting the x-component of the projectile's motion.

2. [3] Suppose that a car traveling to the east (chosen as the $+x$ direction) begins to slow down as it approaches a traffic light. Which of the following statements concerning its acceleration is TRUE?

(Choose one statement; *explain/derive* your choice in the space below.)

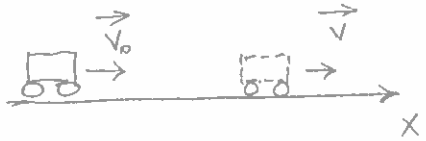
(a) The car is decelerating, and its acceleration is positive.

→ (b) The car is decelerating, and its acceleration is negative.

(c) The acceleration is zero.

(d) The car is accelerating, and its acceleration is positive.

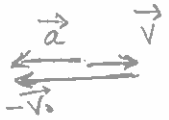
(e) The car is accelerating, and its acceleration is negative.



} "slow down" ⟺ decelerating ($v < v_0$)

Also, $\vec{a} = \frac{\Delta\vec{v}}{\Delta t} \rightarrow \vec{a} \propto \Delta\vec{v} \rightarrow$ vectors $\vec{a}$ and $\Delta\vec{v}$ point in same direction

$\Delta\vec{v} = \vec{v} - \vec{v}_0$:
$= \vec{v} + (-\vec{v}_0)$



∴ $\vec{a}$ points in negative-x direction and acceleration is negative.

3. [4] A horse-pulled wagon begins to move (from rest) at time $t = 0.0$ second with a constant acceleration, along a flat trail. Suppose that the wagon covers a distance of 3.0 meters between $t = 2.5$ seconds and time $t = 5.0$ seconds. Find the wagon's acceleration.

Constant acceleration : $x = x_0 + v_0 t + \frac{at^2}{2}$; let $x_0 = 0$

@ $t_1 = 2.5\,s$: $x_1 = \frac{a}{2}(2.5)^2 = 3.13\,a$

@ $t_2 = 5.0\,s$: $x_2 = \frac{a}{2}(5)^2 = 12.5\,a$

$\therefore \quad x_2 - x_1 = 3$

$12.5a - 3.13a = 3$

$9.4a = 3$

$a = 0.32\ m/s^2$

4. [5] A baseball is tossed straight up with a speed of 24 m/s.

(a) What is the baseball's speed when it reaches a height of 14 m?

(b) From the moment the ball is thrown, calculate how much time it takes to reach this height.

(c) Explain why there are *two* answers to part (b).

(a) "tossed straight up" → free fall; constant "a"

$V^2 = V_0^2 + 2a\Delta y$

$= 24^2 + 2(-9.81)(14)$

$= 301.3 \rightarrow V = \pm 17.4$ m/s

↑ ball passes $y = 14$m both on the way up and then on the way down.

(b) $V = V_0 - gt \Rightarrow t = \dfrac{V_0 - V}{g}$

- $V = +17.4$ m/s : $t = \dfrac{24 - 17.4}{9.81} = 0.67$ s
- $V = -17.4$ m/s : $t = \dfrac{24 - (-17.4)}{9.81} = 4.22$ s

(c) please see part (a) for explanation.

5. [5] Suppose that the position of an object, measured from the origin of an (x, y) coordinate system, is given by:

$$\mathbf{r}(t) = (2.2\ t^2)\ \mathbf{i} + (0.9\ t)\ \mathbf{j}$$

(a) At $t = 3.0$ seconds, how far is the object from the origin?

$$\vec{r}(t=3) = (2.2 \cdot 3^2)\,\hat{i} + (0.9 \cdot 3)\,\hat{j}$$
$$= 19.8\,\hat{i} + 2.7\,\hat{j}$$

$$\therefore \quad r = \sqrt{r_x^2 + r_y^2} = \sqrt{19.8^2 + 2.7^2} = 20 \ [m]$$

(b) What are the object's velocity $\mathbf{v}(t)$ and acceleration $\mathbf{a}(t)$?

$$\vec{v}(t) = \frac{d\vec{r}}{dt} = \left[\frac{d}{dt}(2.2t^2)\right]\hat{i} + \left[\frac{d}{dt}(0.9t)\right]\hat{j}$$
$$= 4.4t\,\hat{i} + 0.9\,\hat{j}$$

$$\vec{a}(t) = \frac{d\vec{v}}{dt} = 4.4\,\hat{i}$$

20

[20] total marks