Arts & Science 2D06

Quiz #1 2014 Sept 18 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: $x = (-b \pm \sqrt{b^2 - 4ac})/2a$

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

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1. [4] Two bricks are dropped from a bridge and from rest; the second brick is dropped 1 second after the first. As time passes by, the difference in their speeds:

(*Explain/derive* your choice in the space below; ignore air resistance.)

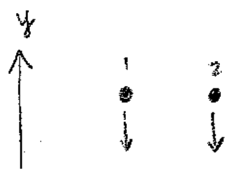
(a) increases.

→ (b) stays the same.

(c) decreases.

(d) increases at first, but then stays the same.

(e) decreases at first, but then stays the same.



$V_1 = V_0 - gt_1$

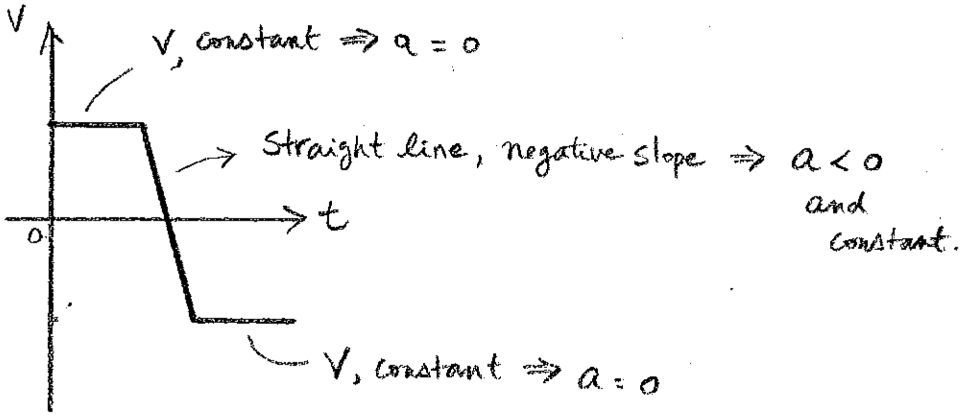
$V_2 = V_0 - g(t_1 - 1)$

$\therefore \quad V_1 - V_2 = V_0 - gt_1 - V_0 + g(t_1 - 1)$ } after ② is released

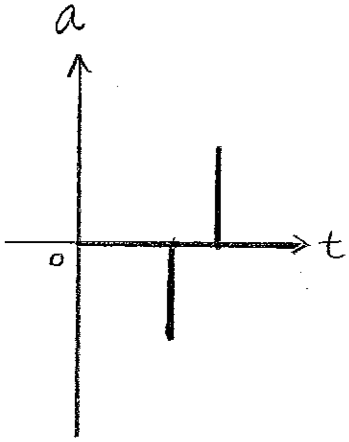
$= V_0 - gt_1 - V_0 + gt_1 - g$

$= -g$

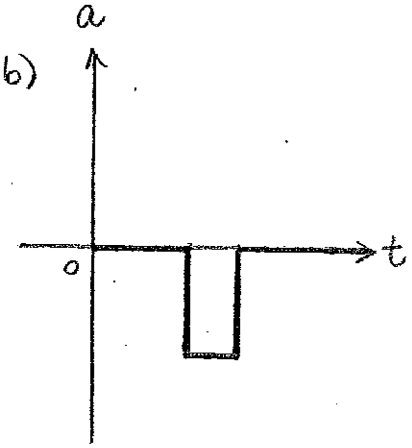
2. [3] Suppose that the velocity of a spaceship changes with time as shown in the plot below. Which option best represents the ship's acceleration as a function of time? (No need to explain/derive.)



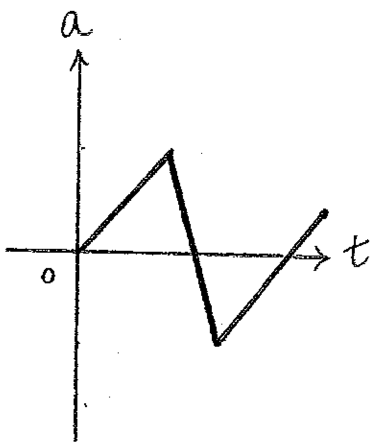
(a)



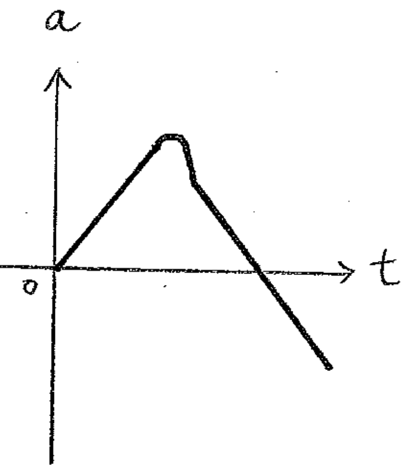
→ (b)



(c)

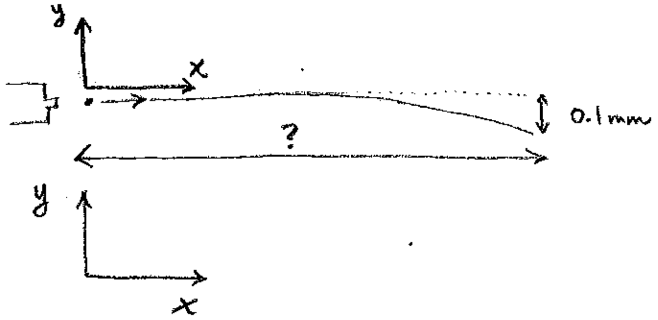


(d)



3. [5] Consider electrons that are initially shot out in the horizontal direction with a speed of 4×10^6 m/s. Through what *horizontal* distance would they have to travel for their *vertical* fall to be 0.1 mm?

(Assume the electrons are traveling in a vacuum tube, *i.e.*, ignore "air" resistance.)



$\vec{V}_0 = V_{0x}\,\hat{i} = (4\times10^6\,m/s)\,\hat{i}$

$\Delta y = y_f - y_0 = -0.1\,mm = -10^{-4}\,m$

$\vec{a} = g(-\hat{j}) = (-9.81\,m/s^2)\,\hat{j}$

$(V_{0y} = 0)$

- let $x_0 = 0$; then $x = V_{0x} t$, so we need the time
- We know,

$$\Delta y = \cancel{V_{0y} t}^{\,0} + \frac{a}{2}t^2$$

$$-10^{-4} = -4.9\,t^2$$

$$t^2 = 2.0\times10^{-5}$$

$$\therefore t = 4.5\times10^{-3}\,s$$

and therefore $x = (4\times10^6)\,m/s\cdot(4.5\times10^{-3})\,s = 18000\,m$

(or 18 km)

4. [5] The speed of a boat is given by the expression

$$v(t) = 3.0 + 2.0\ t^3$$

where v is given in units of m/s and the time is measured with a stopwatch. Find the boat's position as a function of time if it's located at $x = 1.0$ m when the stopwatch is started ($t = 0$).

$$V = \frac{dx}{dt}$$

$$\therefore \quad \frac{dx}{dt} = 3.0 + 2.0\, t^3$$

$$\int dx = \int (3.0 + 2.0 t^3)\, dt$$

$$x = 3.0t + \frac{2.0t^4}{4} + C$$

$$= 3.0t + 0.5t^4 + C \text{ , where } C = \text{constant}$$

To find C: $x(t=0) = 1.0\,m$

$$\therefore \quad 1.0\,m = 3.0(0) + 0.5(0) + C$$

$$C = 1.0\,m$$

and $\underline{x(t) = 3.0t + 0.5t^4 + 1.0}$

5. [3] A pilot drops a package of supplies from a plane while flying horizontally at constant speed. When the package hits the ground, the *horizontal* location of the package will:

(*Explain/derive* your choice in the space below, and ignore air resistance.)

(a) be behind the package.

→(b) be above the package.

(c) be ahead of the package.

(d) depend on the plane's speed when the package was released.

(e) depend on the weight of the package when it was released.

- Viewed from the ground:

  package has V_{0x} equal to that of the plane.

∵ package only accelerates (g) in the vertical direction, so its V_{0x} remains unchanged as it falls.

∴ package will cover the same horizontal distance as the plane ⇒ option (b) is correct.

(See also "Conceptual Example 3-6" in textbook)

[20] total marks