SJPO Training
Kinematics Problem Set

Tan Jing Long
Hwa Chong Institution

April 16, 2016

Warm-up Questions

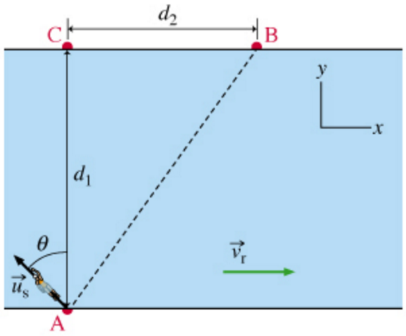
1. A car accelerates from 4.0 m/s to 24 m/s at a rate of 3.0 m/s^2. How far does it travel while accelerating?
   A. 56 m
   B. 93 m
   C. 158 m
   D. 195 m
   E. 279 m

Solution: B

2. Two projectiles are launched with identical speeds of 30 m/s and at angles at 40° and 50° with the horizontal, respectively. The difference between the flight times of the two projectiles is closest to:
   A. 2/3 s
   B. 3/4 s
   C. 4/5 s
   D. 5/6 s
   E. 6/7 s

Solution: B

3. A swimmer wants to cross a river, from point A to point B, as shown in the figure. The distances d_1 and d_2 are 200 m and 150 m respectively. The speed of the river current, v_r is 5.00 km/h. Suppose that the swimmers velocity relative to the watermakes an angle of $\theta = 45.0°$ with the line AC as indicated in the figure. To directly reach point B, what speed u_s, relative to the water, should the swimmer have?
   A. 3.03 km/h
   B. 4.04 km/h
   C. 5.05 km/h
   D. 6.06 km/h
   E. 7.07 km/h



Solution: B

Conceptual Questions

4. Two identical balls are at rest and side by side at the top of a hill. You let one ball A, start rolling down the hill. A little later, you start the second ball, B, down the hill by giving it a shove. The second ball rolls down the hill along a line parallel to the path of the first ball and passes it. At the instant ball B passes ball A,

   A. only the displacement and velocity are the same for both balls.

   B. only the displacement and the acceleration are the same for both balls.

   C. only the velocity and acceleration are the same for both balls.

   D. the displacement, velocity and acclereation are the same for both balls.

   E. the displacement, velocity and acclereation are all different for both balls.

Solution: B

5. Raindrops fall vertically down to the ground with a speed of 10 m/s. If we place a hollow cylinder of cross-sectional area 80 cm^2, height 10 cm on the ground, the height of water in the cylinder after 30 min is 1 cm. Suppose there is a gust under which the raindrops fall 30° to the vertical. How long would it take to fill the cylinder up to the same level?

   A. more than 30 min

   B. 30 min

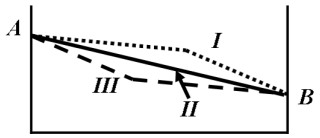
   C. less than 15 min

   D. 15 min

   E. 26 min

Solution: B

6. A marble rolls from A to B via one of the three possible paths I, II and III. By which path will it take the shortest time to reach B?



A. I

B. II

C. III

D. I and III both take the shortest.

E. All take the same time.

Solution: C

7. A rock is thrown vertically upwards with initial speed u. Assume a friction force proportional to $-\overrightarrow{v}$, where $\overrightarrow{v}$ is the velocity of the rock, and neglect the uptrust exerted by air. Which of the following is correct?

A. The acceration of the rock is always equal to $\overrightarrow{g}$.

B. The acceleration of the rock is equal to $\overrightarrow{g}$ at the top of the flight.

C. The acceleration of the rock is always less than $\overrightarrow{g}$.

D. The speed of the rock upon return to its starting point is u.

Solution: B

8. Ali throws a crumpled piece of paper upwards in air. It moves freely under gravity with some air resistance. Assuming constant air resistance and that the stone returns to the point where it is projected,

1. It takes less time to move upwards than it takes to move downwards.
2. It travels less distance upwards than it travels downwards.
3. The speed at the top of its trajectory is zero.
4. The speed when it returns to the point of projection is less than the speed when it is projected.

A. Only statements 1, 2 and 4 are correct.

B. Only statements 1, 2 and 3 are correct.

C. Only statements 1, 3 and 4 are correct.

D. Only statements 3 and 4 are correct.

E. None of the statements given in 1 to 4 is true.

Solution: C

9. Superman stands on the roof garden of a very tall building on Earth with one ball in each hand. If the red ball is thrown horizontal off the roof and the blue ball is simultaneously dropeed over the edge, which statement is true? Neglect air resistance.

    A. Both balls always hit the ground at the same time with the same speed.

    B. The red ball strikes the ground first with a higher speed than the blue ball.

    C. The blue ball strikes the ground first, but with a lower speed than the red ball.

    D. Both balls always hit the ground at the same time, but the red ball has a higher speed just before it strikes the ground.

    E. If the initial speed of the red ball is high enough, it may strike the ground later with a higher speed than the blue ball.

Solution: E

Worked Questions

10. A juggler is throwing ball into the air. He throw one whenever the previous one is at its highest point. How high do the balls rise if he throws n balls each second. Acceleration due to gravity is g.

    A. $g/4n^2$

    B. $2n^2g$

    C. $g/2n^2$

    D. g/n

    E. n/g

Solution: C

11. A fireworks rocket explodes at height h, the peak of its vertical trajectory. It throws out burning fragments in all directions, but all at the same speed v. Pellets of solidified metal fall to the ground without air resistance. Find the smallest angle that the final velocity of an impacting fragment makes with the horizontal.

    A. 0

    B. $\arctan\left(\sqrt{2gh}/v\right)$

    C. $\arctan\left(\sqrt{2gh+v^2}/v\right)$

    D. $\arctan\left(v/\sqrt{2gh+v^2}\right)$

    E. $\arctan\left(v/\sqrt{2gh}\right)$

Solution: B

12. An object falls freely through air. What is the ratio of the distance fallen in three consecutive seconds (in sequential order)?

    A. 1 : 2 : 3

    B. 1 : 4 : 9

C. $1 : 3 : 5$
D. $1 : \sqrt{2} : \sqrt{3}$
E. $1 : \sqrt{2} - 1 : \sqrt{3} - 1$

Solution: C

13. Consider a train that can speed up with an acceleration of $20\,\mathrm{cm/s^2}$ and slow down with a deceleration of $100\,\mathrm{cm/s^2}$. Find the minimum time for the train to travel between two stations 2 km apart. You may assume that the train has to stop at every station.

A. 33.3 s
B. 57.7 s
C. 81.6 s
D. 141 s
E. 155 s

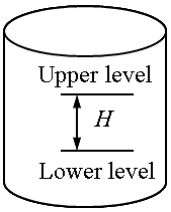
Solution: E

14. A marathon runner runs at a steady speed of 15 km/h. When the runner is 7.5 km from the finish, a bird begin flying from the runner to the finish at 30 km/h. When the bird reaches the finish line, it turns around and flies back to the runner, and then turns around again, repeating the back-and-forth trips until the runner reachers the finish line. How many kilometers does the bird travel?

A. 10 km
B. 15 km
C. 20 km
D. 30 km
E. 45 km

Solution: B

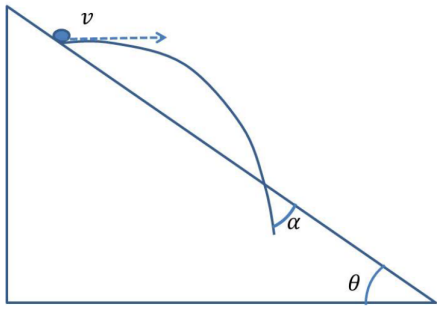
15. In an experiment for measuring g, a particle is thrown vertically up in a evacuated tube and allowed to fall down. ΔT_L is the time interval when the particle crosses a lower level in the tube while going up and while falling down. Similarly ΔT_H is the time interval when it crosses an upper level while going up and while falling down. H is the distance between the two levels as shown in the figure. Determine the expression which give g.



Solution:

$$\frac{8H}{\Delta T_L^2 - \Delta T_H^2}$$

16. A ball is thrown out horizontally from a slope, which is inclined at an angle θ from the ground, as shown in the figure below. The ball is thrown at speeds v_1 and v_2 and makes acute angles α_1 and α_2 with the slope respectively. If v_1 is greater than v_2,



A. $\alpha_1 = \alpha_2$
B. $\alpha_1 > \alpha_2$
C. $\alpha_1 < \alpha_2$
D. $\alpha_1 < \theta$
E. It is not possible to infer as the mass of the ball is not given.

Solution: A