ENG1004: Engineering Physics

Additional kinematics questions

August 28, 2023

Question 1

A car's velocity as a function of time is given by $v_x = \alpha + \beta t^2$, where α = 3.00 m/s and β = 0.100 m/s^3.

(a) Calculate the average acceleration for the time interval t = 0 to t = 5.00 s.

(b) Calculate the instantaneous acceleration for t = 0 and t = 5.00 s.

(c) Draw the $v_x - t$ and the $a_x - t$ graphs for the car's motion between t = 0 and t = 5.00 s.

Adapted from Young and Freedman, "University Physics with Modern Physics", 14th Edition, Pearson, 2015.

Answers

(a) a_{xavg} = 0.5 m/s^2; (b) a_x (t = 0 s) = 0 m/s^2; a_x (t = 5 s) = 1 m/s^2

Question 2

A toy rocket is rising at a constant speed of 20 m/s. When it is 24 m above the ground, a bolt comes loose.

(a) How long does the bolt take to land?
(b) What is its maximum height?
(c) At what speed does it hit the ground?

Adapted from Benson, "University Physics", Revised Edition, John Wiley & Sons, inc., 1996.

Answer

(a) 5.1 s; (b) 44 m; (c) -30 m/s

Question 3

A stone is thrown vertically upward. On its way up it passes point A with speed v, and point B, 3.00 m higher than A, with speed $\frac{1}{2}v$. Calculate (a) the speed v and (b) the maximum height reached by the stone above point B.

Answer

(a) 8.85 m/s; (b) 1.00 m

Adapted from Walker, "Halliday and Resnick Fundamentals of Physics", 9th Edition, John Wiley & Sons, Inc., 2011.

Question 4

A flower pot falls off a balcony. It takes 0.10 s to pass a window of height 1.25 m. From what height above the bottom of the window did it fall?

Answer

Height above window: 8.6 m

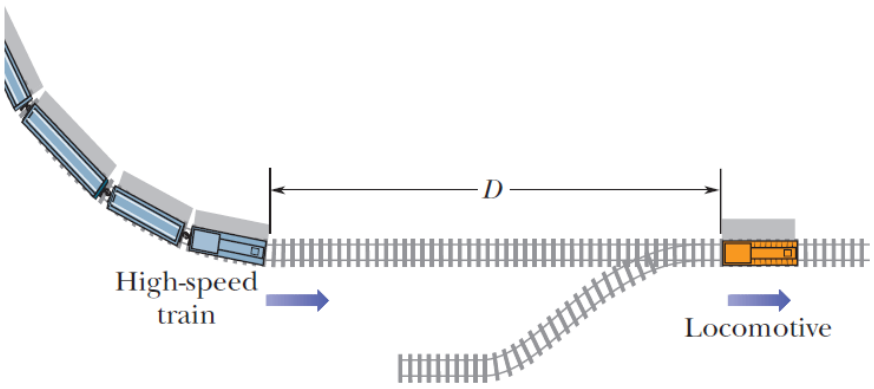
Adapted from Benson, "University Physics", Revised Edition, John Wiley & Sons, inc., 1996.

Question 5

When a high speed passenger train traveling at 161 km/h rounds a bend, the engineer is shocked to see that a locomotive has improperly entered onto the track from a siding and is a distance D = 676 m ahead. The locomotive is moving at 29.0 km/h. The engineer of the high-speed train immediately applies the brakes.

(a) What must be the magnitude of the resulting constant deceleration if a collision is to be just avoided?

(b) Assume that the engineer is at x = 0 when, at t = 0, he first spots the locomotive. Sketch $x(t)$ curves for the locomotive and high speed train for the cases in which a collision is just avoided and is not quite avoided.



Adapted from Walker, "Halliday and Resnick Fundamentals of Physics", 9th Edition, John Wiley & Sons, Inc., 2011.

Answer

(a) a_x = 0.994 m/s^2

Question 6

Crickets Chirpy and Milada jump from the top of a vertical cliff. Chirpy drops downward and reaches the ground in 2.70 s, while Milada jumps horizontally with an initial speed of 95.0 cm/s. How tall is the cliff and how far from the base of the cliff will Milada hit the ground? Ignore air resistance.

Adapted from Young and Freedman, "University Physics with Modern Physics", 14th Edition, Pearson, 2015.

Answers

Height of cliff: 35.7 m. Horizontal distance: 2.57 m

Question 7

A medieval catapult could project a 75.0 kg stone at 50 m/s at 30.0º above the horizontal. Suppose the target is a fortress wall of height 12.0 m at a horizontal distance of 200. m.

(a) Would the stone hit the wall?
(b) If so, at what height?
(c) And at what angle?

Adapted from Benson, "University Physics", Revised Edition, John Wiley & Sons, inc., 1996.

Answers

(a) Yes; (b) h = 10.9 m; (c) 335º

Question 8

A doughnut-shaped space station has an outer rim of radius of 1 km. With what period should it rotate for a person at the rim to experience an acceleration of $g/5$?

Adapted from Benson, "University Physics", Revised Edition, John Wiley & Sons, inc., 1996.

Answer

T = 142 s

Question 9

A plane, diving with constant speed at an angle of 53.0° with the vertical, releases a projectile at an altitude of 730 m. The projectile hits the ground 5.00 s after release. (a) What is the speed of

the plane? (b) How far does the projectile travel horizontally during its flight? What are the (c) horizontal and (d) vertical components of its velocity just before striking the ground?

Adapted from Walker, "Halliday and Resnick Fundamentals of Physics", 9th Edition, John Wiley & Sons, Inc., 2011.

Answer

(a) 202 m/s; (b) 806 m; (c) 161 m/s; (d) - 171 m/s

Question 10 *

A monkey escapes from the zoo and climbs a tree. After failing to entice the monkey down, the zookeeper fires a tranquilizer dart directly at the monkey. The monkey lets go at the instant the dart leaves the gun. Show that the dart will always hit the monkey, provided that the dart reaches the monkey before he hits the ground and runs away.

Adapted from Young and Freedman, "University Physics with Modern Physics", 14th Edition, Pearson, 2015.