Physics 1145 Fall 2021 Test 1 (4 pages)

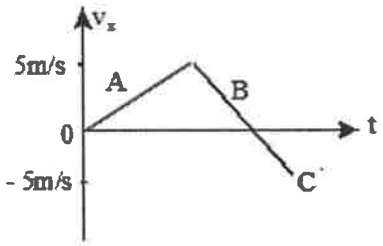
Name: Solution **September 22, 2021** **Total Score:** 120 /120

$x = x_i + v_{ix}\Delta t + \frac{1}{2} a_x(\Delta t)^2$ $v_x = v_{ix} + a_x\Delta t$ $v_x^2 = v_{ix}^2 + 2\,a_x(x - x_i)$

$y = y_i + v_{iy}\Delta t + \frac{1}{2} a_y(\Delta t)^2$ $v_y = v_{iy} + a_y\Delta t$ $v_y^2 = v_{iy}^2 + 2\,a_y(y - y_i)$

Free fall acceleration: g= 9.8m/s^2 Centripetal acceleration: $a_c = \frac{v^2}{R}$ $v = \frac{2\pi R}{T}$

B 1.(5) The motion of an object is described by the v_x-t-diagram at the right. During which segment of the motion is the object slowing down?

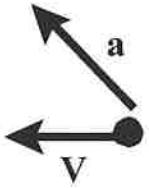


A) A B) B C) C D) both B and C

C 2. (5) A ball is thrown with an initial speed at θ=0° above the horizontal. When it has reached half its maximum height, which quantity is the same as just after launch?

A) speed B) velocity C) horizontal component of velocity D) vertical component of velocity

D 3. (5) A particle is moving with velocity V. At a particular instant, it experiences an acceleration a as shown in the figure. We know that the particle is:



A) only speeding up B) slowing down and changing direction of motion.

C) only slowing down D) speeding up and changing direction of motion.

D 4.(5) . An object is moving in a circle of a given radius at constant speed. Which is true about the object?

A) Its velocity is constant.

B) Its acceleration is zero.

C) Its acceleration is directed parallel to the velocity vector.

D) The faster the object, the greater its acceleration.

A 5. (5) A particle rotates in a circle with centripetal acceleration a. If the speed is reduced by a factor of 3 without changing the radius, the new acceleration will be

A) 1/9 a B) ⅓ a C) 3 a D) 9 a

$v \to \frac{1}{3}v \Rightarrow a \to \frac{1}{9}a$

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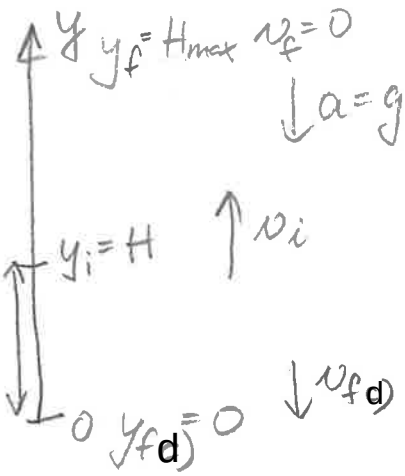
7. (40) A hot air balloon is rising vertically at a constant speed of V_i. When the balloon is at height H above the ground, a passenger inside drops a package which, subsequently, is in free fall.



a) In the space provided at the right, draw a complete diagram with all information needed to solve the tasks below.
Remember, any quantity used in the calculation must be defined in the diagram. You may want to add elements as you go along.

b) Derive an expression for the maximum height H_{max} above the ground reached by the package, in terms of H, V_i, and g.

$v_y^2 = v_{iy}^2 + 2a_y(y - y_i)$ ($v_y = 0$)

$0 = v_i^2 + 2(-g)(H_{max} - H)$

$$H_{max} = \frac{v_i^2}{2g} + H$$

c) Derive an expression for the time it takes the package to reach the highest point, in terms of H, V_i, and g or a subset of these quantities.

$v_y = v_{iy} + a_y \Delta t$ ($v_y = 0$)

$0 = v_i - g\Delta t$

$$\Delta t = \frac{v_i}{g}$$

d) Derive an expression for the speed with which the package hits the ground. You may consider any quantities found in the previous parts as given.

$v_y^2 = v_{iy}^2 + 2a_y(y - y_i)$ ($y = 0$)

$v_y^2 = v_i^2 - 2g(-H)$

$$|v_y| = \sqrt{v_i^2 + 2gH}$$

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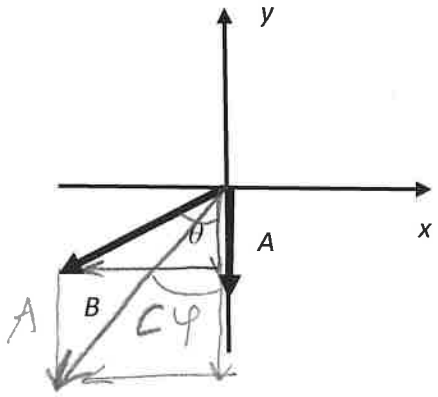
8. (25) In the figure, the magnitudes of the vectors are A= 3 and B=5. The angle θ equals 53°.

a) Calculate the vector components A_x, A_y, B_x, B_y.



$A_x = 0$

$A_y = -A = -3$

$B_x = -B\sin\theta = -5 \cdot \frac{4}{5} = -4$

$B_y = -B\cos\theta = -5 \cdot \frac{3}{5} = -3$

b) The vector $\vec{C} = \vec{A} + \vec{B}$. Sketch vector $\vec{C}$ in the diagram and calculate its components, magnitude, and direction.

$C_x = A_x + B_x = 0 - 4 = -4$

$C_y = A_y + B_y = -3 - 3 = -6$

$C = \sqrt{C_x^2 + C_y^2} = \sqrt{(-4)^2 + (-6)^2} = \sqrt{16 + 36}$

$C = 7.2$

$\tan\varphi = \frac{|C_x|}{|C_y|} = \left|\frac{4}{6}\right|$ $\quad \varphi = 33.7°$

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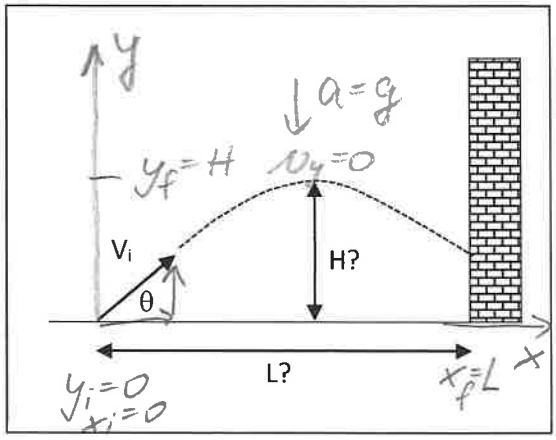
9. (35) A student kicks a soccer ball from the ground level with an initial speed V_i at an angle θ with respect to the horizontal towards a wall that is an unknown horizontal distance away.



a) Complete the diagram on the right with all information necessary to solve the parts below.

b) The ball hits the wall at time Δt after launch. Derive a symbolic expression in terms of given quantities for the horizontal distance L to the wall.

$x = x_i^{\,0} + v_{ix}\Delta t + \frac{1}{2}a_x^{\,0}(\Delta t)^2$

$L = v_i \cos\theta\, \Delta t$

c) Before hitting the wall, the ball first reaches its highest point. Derive a symbolic expression for the maximum height H, in terms of given quantities.

$v_y^{2=0} = v_{iy}^2 + 2a_y(y - y_i)^0$

$0 = (v_i \sin\theta)^2 + 2(-g)(H-0)$

$H = \dfrac{(v_i \sin\theta)^2}{2g}$

d) What are the x- and y-components of the ball's velocity with which it hits the wall?

$v_x = v_{ix} + a_x^{\,0}\Delta t$

$v_x = v_i \cos\theta$

$v_y = v_{iy} + a_y \Delta t$

$v_y = v_i \sin\theta - g\Delta t$

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