KEY

PHYSICS149 TEST 1 Tuesday, October 2, 2001

This 14-question test (each question is worth approximately 7.7 points) is worth 100 points, each question is weighted equally. Please fill out the answer sheet with soft lead pencil. Be sure to give your name, student ID #, date, Course #, Test 1, and SIGN the answer sheet. Be prepared to present your Student picture ID card when handing in your answer sheet. You may keep the sheets with the questions and your work.

Pick the nearest value for your answer (there may be slight round-off errors).

Don't get hung up too long over any one question until you have tried all of them.

You are expected to bring your own sheet of equations and words explaining the equations. Here are a few possibly useful equations. You will need to know when they are valid and when they are not.

$g = 9.8\ m/s^2$ $G = 6.67 \times 10^{-11} Nm^2/kg^2$

$v = v_0 + at$ for each vector component of v and a

$x = x_0 + v_0 t + 1/2\, a t^2$ and ditto for y and z components

$v_x^2 - v_{0x}^2 = 2a(x - x_0)$ etc. average $v_x = \Delta x/\Delta t$ etc.

$x = x_0 + 1/2\,(v_0 + v)t$ etc. average $a = \Delta v/\Delta t$ and etc. for each component

$x = r\cos(\theta)$ $y = r\sin(\theta)$ $\tan(\theta) = y/x$

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1) An elephant has a mass m=2000kg. Express this mass in μg, m = ?

a) 2×10^{-3} μg
b) 2×10^{-6} μg
c) 2×10^{3} μg
d) 2×10^{6} μg
e) 2×10^{9} μg

$m = 2\ kg = 2_{10^3} g = 2 \times 10^3 \times \underbrace{10^6 \mu}\, g$

(Since $\mu = 10^{-6}$)

$m = 2_{10^9} \mu g$

2) Vector A = (200,300). Vector C = A + B = (-300,-200)
What is the length of vector B?

a) 100
b) 413
c) 525
d) 637
e) 707

$\vec{B} = \vec{C} - \vec{A} = (-300, -200) - (200, 300)$

$\vec{B} = (-500, -500)$

length of $\vec{B}$ = $|\vec{B}| = B = \sqrt{500^2 + 500^2} = 500\sqrt{2} = 707.$

V_o t $(t_o = 0)$

3) A car going +37 m/s stops in a straight line in 7.5 seconds.
What is its VECTOR acceleration in 1-Dimension?

NOT $\oplus$

a) ~~4.93 m/s²~~
b) 277.5 m/s²
c) 44.5 m/s²
⇒ d) -4.93 m/s²
e) -277.5 m/s²

$$a = \frac{\Delta v}{\Delta t} = \frac{V_f - V_o}{t_f - t_o} = \frac{0 - 37\,m/s}{7.5\,s}$$

$$a = -4.9333\,m/s^2$$

4) A hockey puck travelling at 6.9 m/s goes 75 m before coming to rest.
What is the magnitude of its acceleration?

a) 0.046 m/s²
b) 0.32 m/s²
c) 0.64 m/s²
d) 3.45 m/s²
e) 0.092 m/s²

$$V^2 - V_o^2 = 2a\,(x - x_o)$$

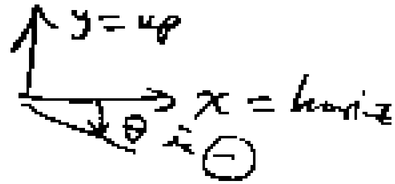
$$0 - (6.9\,m/s)^2 = 2 \cdot a\,(75\,m)$$

$$a = \frac{47.61\,m^2/s^2}{150\,m} = 0.317\,m/s^2$$

5) An airplane is travelling at 150 m/s horizontally and also descending at 30 m/s. How fast is it moving in 3-D?

a) 120 m/s
b) 180 m/s
c) 150 m/s
d) 153 m/s
e) 159 m/s

$\vec{v} = (\text{speed}, \text{angle})$



$\text{Speed} = \sqrt{(150^2 + 30^2)\, m^2/s^2} = \sqrt{23,400\, m^2/s^2}$

$\text{Speed} = |v| = 152.97\, m/s$

6) In the above example, what is the angle of the airplane's path relative to the horizontal?

a) -20.0°
b) 20.0°
c) -30.0°
d) -11.3°
e) 11.3°

$\theta = \tan^{-1}\left(\frac{v_y}{v_x}\right) = \tan^{-1}\left(\frac{-30\, m/s}{+150\, m/s}\right)$

$\theta = \tan^{-1}\left(\frac{-1}{5}\right) = -11.31°$

7) A rock is dropped from a moving train at 15 m/s. Neglecting air resistance, how fast is the rock going (in 3-D) when it hits the ground 4 m below where it was released?

a) 8.9 m/s
b) 15.0 m/s
c) 17.4 m/s
d) 23.9 m/s
e) 31.0 m/s

$\vec{V}_0 = (15\ m/s, 0) = (V_{0x}, V_{0y})$ $\quad\downarrow g$

$\Delta y = -4m$

$\vec{V} = (V_x, V_y)$

$\vec{a} = (a_x, a_y) = (0, -g) = (0, -9.8\ m/s^2)$

$V_x = V_{0x} + \overset{0}{a_x} t = V_x = \text{constant} = 15\ m/s$

$V_y = V_{0y} + a_y t = 0 - 9.8\ m/s^2\ t$ but what is t?

use $V_y^2 - \underset{0}{V_{0y}^2} = 2a\Delta y = 2(-9.8\ m/s^2)(-4m)$

$V_y^2 = 78.4\ m^2/s^2 \qquad V^2 = V_x^2 + V_y^2 = (15\ m/s)^2 + 78.4\ m^2/s^2 = 303.4\ m^2/s^2$

$V = \sqrt{\ } = 17.42\ m/s$

8) A ball is thrown at a 30° angle above horizontal and rises 20 m above its launch point. With what speed was the ball thrown (3-D)?

a) 20 m/s
b) 40 m/s
c) 10 m/s
d) 15 m/s
e) 25 m/s

$\uparrow$ up $\quad \downarrow g$

$V_0 = ?$ $\quad 30°$

$V_{0y} = V_0 \sin 30°$

$\Delta y = 20\ m$

$a_y = -g = -9.8\ m/s^2$

$\underset{(=0)}{V_{top,y}^2} - V_{0y}^2 = 2a\Delta y = 2(-9.8\ m/s^2)(+20\ m)$

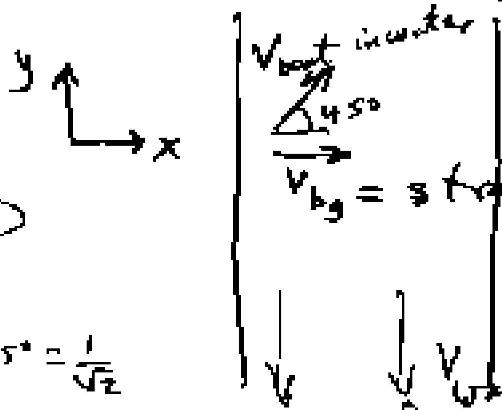
$0 - V_{0y}^2 = -392\ m^2/s^2$

$V_{0y} = \sqrt{\ } = 19.7989\ m/s = V_0 \sin 30° = V_0 (0.5)$

$V_0 = \frac{V_{0y}}{\sin 30°} = \frac{V_{0y}}{1/2} = 2V_{0y} = 39.597\ m/s$

9) A boat crossing a river which is 2 km wide, aims 45° upstream (that is the direction of the boat's velocity relative to the water). The boat reaches the opposite side in 13 minutes. How fast is the river flowing if the boat lands directly across from its starting point?

a) 1.41 m/s
b) 1.63 m/s
c) 1.81 m/s
~~d) 2.07 m/s~~
e) 2.56 m/s



V_{bg} = straight across $= \dfrac{2\,km\ (10^3)}{13\,min \times 60\,\frac{sec}{min}} = 2.564\ m/s$

? speed

$V_{water} = (-)V_{wg}$ (with respect to the ground) purely in $-y$ direction

$\cos 45° = \sin 45° = \frac{1}{\sqrt{2}}$

$V_{bg}\big|_x = V_{bw} \cdot \cos 45° + \overset{0}{V_{wg}\big|_x}$

$V_{bg}\big|_y = 0 = \underbrace{V_{bw} \sin 45°}_{y\ \text{component}} - V_{wg}$

$V_{wg} = V_{bw} \sin 45° = V_{bw} \cos 45° = V_{bg} = 2.564\ m/s$

10) An astronaut falls towards an asteroid with approximately constant acceleration, a_z, and her distance from it, z, varies as

$z = -100 m/s(t) - 100 m/s^2(t^2) = v_{oz} t + \frac{1}{2} a_z t^2$

What is her velocity at time t = 3s? Hint: identify $0.5\,a_z$ and v_{oz} from this equation and then use another equation to find v in terms of a_z and v_{oz}.

$V_{oz} = -100\ m/s$

$\frac{1}{2} a_z = -100\ m/s^2$

$a_z = -200\ m/s^2$

~~a) 400 m/s~~
b) -700 m/s
~~c) -250 m/s~~
~~d) 400 m/s~~
e) 700 m/s

(e): wrong sign

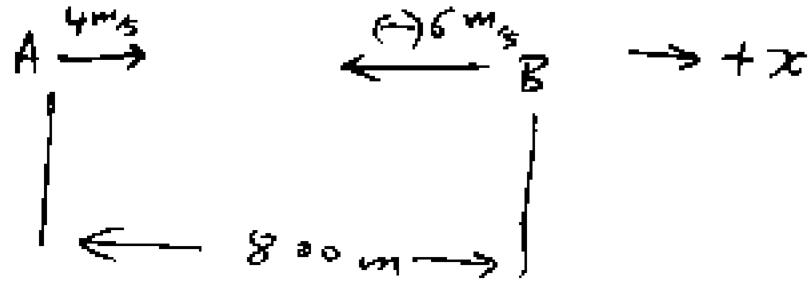
$V_z = V_{oz} + a_z t$

$V_z = -100\ m/s - 200\ m/s^2 (3s)$

$= -100 - 600 = -700\ m/s$

11) Two runners start 800 m apart and run towards each other. Runner A runs with speed 4 m/s, runner B with speed 6 m/s. A fly, with speed 15 m/s, flies back and forth from one runner to the other, continuously, starting from runner A. How far does the fly fly before it is crushed between the two runners (total path length)?

a) 600 m
b) 900 m
c) 1200 m
~~d) 1500 m~~
e) 2000 m



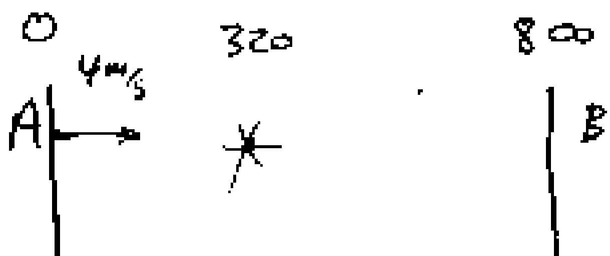
$V_{relative} = 10 \text{ m/s}$

$$t_{collide} = \frac{\text{distance [m]}}{\text{speed [m/s]}} = \frac{800\text{ m}}{10\text{ m/s}} = 80\text{ s}$$

fly's distance = speed · time = 15 m/s * 80 s = 1200 m

12) In the above example, what is the fly's net DISPLACEMENT (from the starting point at runner A) at the time it is crushed?

a) 160 m
b) 240 m
c) 320 m
d) 400 m
e) 600 m

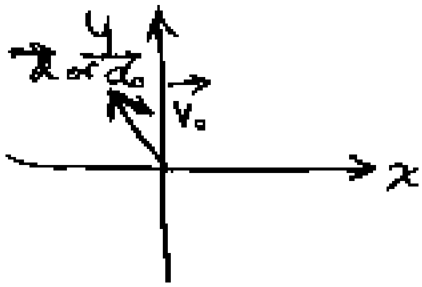


A's displacement = 4 m/s * 80 s time until collision
= 320 m

and that's where A, B, + fly are at collision time, relative to A's + fly's starting position.

13) An object moves with initial vector velocity v_o = (-360,+480)m/s and constant acceleration (30,-30)m/s^2. At what time (relative to to=0) is the object's velocity vector pointed at 90° to the x-axis? $t_o = 0$

a) 12 s
b) 16 s
c) 1.33 s
d) 6 s
e) 0 s



$$\vec{V} = \vec{V}_o + \vec{a}\,t$$

$$\vec{V} = (-360, +480)\,\tfrac{m}{s} + (30, -30)\,\tfrac{m}{s^2}\,(t)$$

$$\vec{V} = (-360 + 30t,\ +480 - 30t)$$

when is $\vec{V}$ pointed along $+\hat{y}$ (i.e. $V_x = 0$, $V_y > 0$) ?

$V_x = -360 + 30t = 0 \qquad t = 360/30 = 12s$

14) What is the average velocity of the above object over the time interval between t = 2 s and t = 12 s ?

a) (-150, 270) m/s
b) (-480, 360) m/s
c) (0, 120) m/s
d) (-120, 0) m/s
e) (60, -60) m/s

$$\vec{\bar{V}} = \tfrac{1}{2}\left(\vec{V}_1 + \vec{V}_2\right)$$

$$\vec{\bar{V}} = \tfrac{1}{2}\left((-360 + 30\cdot 2,\ 480 - 30\cdot 2) + (-360 + 30\cdot 12,\ 480 - 30\cdot 12) \right)$$

Solve + add, OR,

Since $\vec{a}$ = constant,
the average occurs halfway through the time interval, at

$$t_{avg} = \frac{2 + 12}{2} = 7 \text{ seconds}$$

$$\vec{\bar{V}} = (-360 + 30\cdot 7,\ 480 - 30\cdot 7) = (-360 + 210,\ 480 - 210)$$

$$\vec{\bar{V}} = (-150,\ +270)\ \tfrac{m}{s}$$