*Section instructor*____________________ *Section number*__________

Last/First name A. DANYLOV

Last 3 Digits of Student ID Number: __________

Show all work. Show all formulas used for each problem prior to substitution of numbers. Label diagrams and include appropriate units for your answers. *You may use an alphanumeric calculator during the exam as long as you do not program any formulas into memory. By using an alphanumeric calculator you agree to allow us to check its memory during the exam. Simple scientific calculators are always OK!*

A Formula Sheet Is Attached To The Back Of This Examination

Be Prepared to Show your Student ID Card

Score on each problem:

1. (20) ____

2. (20) ____

3. (20) ____

4. (20) ____

Total Score (out of 80 pts) ____

1. Conceptual Questions

(20 point) Put a circle around the letter that you think is the best answer.

1.1. (5pts) A biker is riding a bike forward and speeding up. What are the signs of ω and α of a wheel?

A) ω is positive and α is positive

B) ω is positive and α is negative

C) ω is negative and α is negative

D) ω is negative and α is positive

E) ω is positive and α is zero

$\omega < 0$ (cw)

$$\alpha = \frac{\omega_f - \omega_i}{\Delta t} = \left\| \begin{matrix}\text{speeding up} \\ |\omega_f| > |\omega_i|\end{matrix} \right\| = \frac{(-|\omega_f|) - (-|\omega_i|)}{\Delta t} < 0$$

1.2. (5pts) The figure shows a graph of the velocity as a function of time for an object traveling up and down along a straight-line path. Find a displacement of the object over the time period between 0 and 2 seconds.

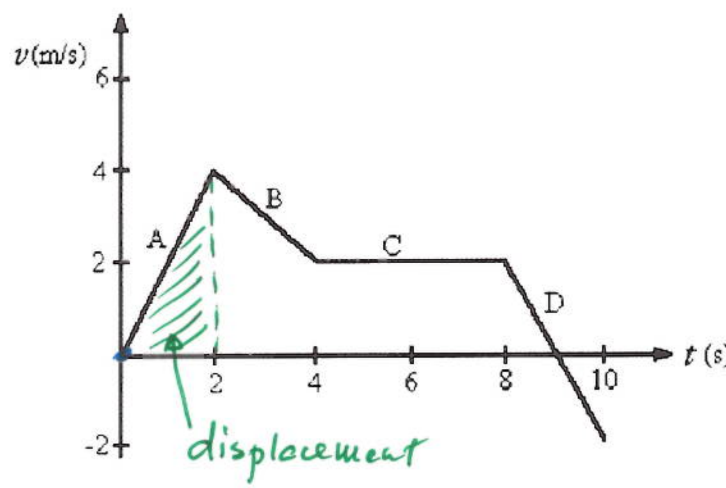
A) -4 m

B) -8 m

C) 2 m

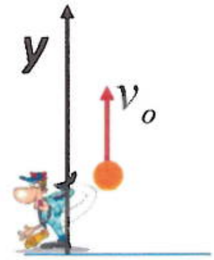
D) 4 m

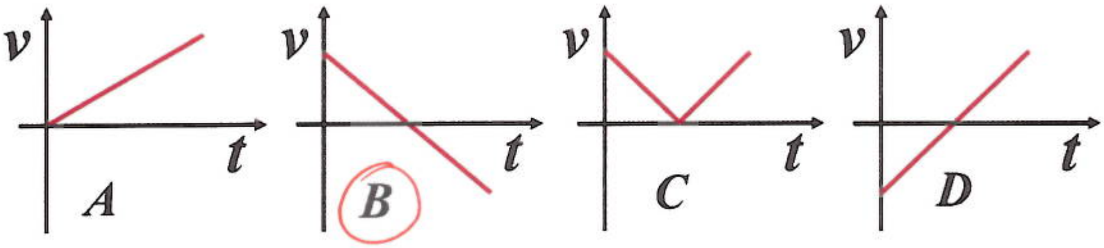
E) None of the above



$$\text{Displ.} = \text{Area} = \frac{1}{2} \cdot (4-0)\,\text{m/s} \cdot (2-0)\,\text{s} = 4\,\text{m}$$

1.3. (5pts) A person throws a ball upward into the air with an initial nonzero velocity. Right after the ball leaves your hand and before it hits the floor, which of the plots represents the v vs. t graph for this motion? Y axis is upward.



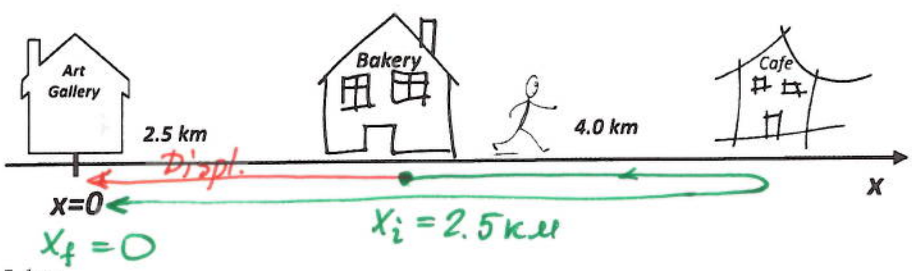


1.4. (5pts) What is $6.472 + 1.2$ to the proper level of uncertainty?

$\approx 7.672 \approx 7.7$

A) 7.6
B) 7.672
C) 7.62
D) 7.7
E) None of the above

1.5. (5pts) Refer to the figure below. If you start from the Bakery, travel to the Cafe, and then to the Art Gallery, what is your displacement?



A) 6.5 km

B) 2.5 km

C) -2.5 km

D) -1.5 km

E) 1.5 km

Displ. $= \Delta x = x_f - x_i = 0 - 2.5$ km $= -2.5$ km

Problem 2. (20 pts)

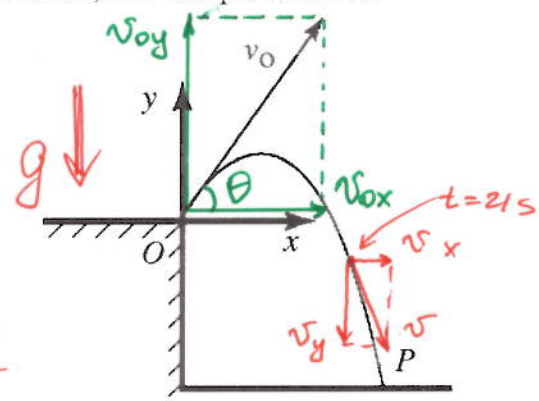
A projectile is fired from point 0 at the edge of a cliff, with initial velocity components of $v_{0x} = 60$ m/s and $v_{0y} = 175$ m/s, as shown in the figure. The projectile rises and then falls into the sea at point P. The time of flight of the projectile is 40.0 s, and it experiences no appreciable air resistance in flight.

a) (3pts) At which angle is the projectile fired?

b) (7pts) What is the magnitude of the velocity of the projectile 21.0 s after it is fired?

c) (7pts) What is the height of the cliff?

d) (3pts) How far from the cliff does the ball hit the sea surface?



a) $\tan\theta = \frac{v_{0y}}{v_{0x}} \Rightarrow \theta = \tan^{-1}\left(\frac{175\ m/s}{60\ m/s}\right) = 71.07°$

$\begin{cases} a_y = -g \\ a_x = 0 \end{cases}$

b) @ $t = 21s$.

$v_x = v_{0x} = 60\ m/s$

$v_y = v_{0y} - g \cdot t = 175\ m/s - 9.8\ m/s^2 \cdot 21\ s = 175\ m/s - 205.8\ m/s = -30.8\ m/s$ ← it points downward

$v = \sqrt{v_x^2 + v_y^2} = \sqrt{(60\ m/s)^2 + (-30.8\ m/s)^2} = 67.4\ m/s$

c) $y = y_0 + v_{0y} \cdot t - \frac{gt^2}{2}$ (with $y = -h$, $y_0 = 0$)

$\frac{gt^2}{2} - v_{0y} \cdot t - h = 0 \Rightarrow h = \frac{gt^2}{2} - v_{0y} \cdot t = \frac{(9.8\ m/s^2) \cdot (40s)^2}{2} - (175\ m/s) \cdot 40s$

$h = 840\ m$

d) $x = x_0 + v_{0x} \cdot t = 60\ m/s \cdot 40s = 2400\ m$ (with $x_0 = 0$)

Problem 3. (20 pts)

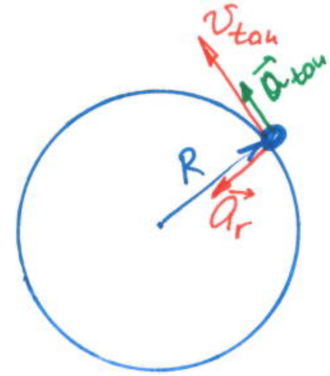
A satellite orbits the earth a distance of 3.00×10^7 m from the center of the Earth and takes 8.6 hours for each revolution about the earth. Assume that the rotational motion is uniform.

a) *(6pts) Find the magnitude of the satellite's tangential velocity.*

b) *(4pts) Find the satellite's angular velocity.*

c) *(6pts) Find the satellite's centripetal acceleration?*

d) *(4pts) What is the satellite's tangential acceleration?*



$R = 3.0 \cdot 10^7 m$; $T = 8.6 h$

a) $$v_{tan} = \frac{2\pi R}{T} = \frac{2\pi \cdot 3 \cdot 10^7 m}{8.6 h \cdot \left(\frac{60 min}{1 h}\right) \cdot \left(\frac{60 s}{1 min}\right)} = 2.039 \cdot 10^3 m/s \approx 2 \, km/s$$

b) $$v_{tan} = \omega \cdot R \Rightarrow \omega = \frac{v_{tan}}{R} = \frac{2.039 \cdot 10^3 m/s}{3.00 \cdot 10^7 m} = 6.79 \cdot 10^{-4} \frac{rad}{s}$$

c) $$a_r = \frac{v_{tan}^2}{R} = \frac{(2.039 \cdot 10^3 m/s)^2}{3.0 \cdot 10^7 m} = 0.139 \, m/s^2$$

d) $a_{tan} = 0$, since the circular rotation is uniform (v_t = con

Problem 4 (20 pts).

Vector $\vec{\mathbf{A}}$ has a magnitude of 5.5 cm and points along the x-axis. Vector $\vec{\mathbf{B}}$ has a magnitude of 7.5 cm and points at +30° above the negative x-axis.

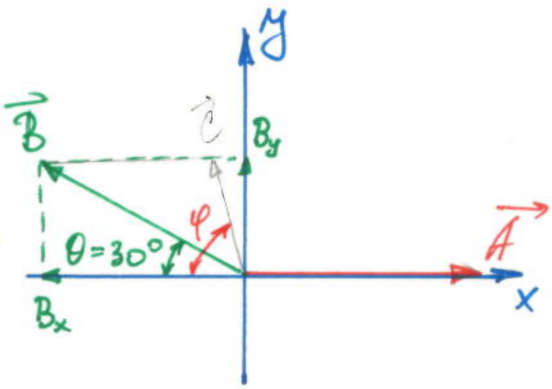
a) (5pts) Determine the x and y components of Vector $\vec{\mathbf{A}}$.

b) (5pts) Determine the x and y components of Vector $\vec{\mathbf{B}}$.

c) (5pts) Determine x and y components of the sum of these two vectors.

d) (5pts) Determine the magnitude and direction of the sum of these two vectors.

a) $\begin{cases} A_x = 5.5\,\text{cm} \\ A_y = 0 \end{cases}$



b) $\begin{cases} B_x = -B \cdot \cos 30° = -7.5\,\text{cm} \cdot \frac{\sqrt{3}}{2} = -6.495\,\text{cm} \\ B_y = B \cdot \sin 30° = 7.5\,\text{cm} \cdot \frac{1}{2} = 3.75\,\text{cm} \end{cases}$

c) $\vec{A} + \vec{B} = \vec{C}$

$\begin{cases} C_x = A_x + B_x = 5.5\,\text{cm} - 6.495\,\text{cm} = -0.995\,\text{cm} \\ C_y = A_y + B_y = 0 + 3.75\,\text{cm} = 3.75\,\text{cm} \end{cases}$

It's in the 2nd quarter.

d) $C = \sqrt{C_x^2 + C_y^2} = \sqrt{(-0.995\,\text{cm})^2 + (3.75\,\text{cm})^2} = 3.88\,\text{cm}$

$\tan\varphi = \frac{|C_y|}{|C_x|} \Rightarrow \varphi = \tan^{-1}\left(\frac{3.75}{0.995}\right) = 75.14°$ above $-x$ axis