Phys 111
Fall 2023

General Physics: Class Exam I

18 September 2023

Name: _____ **Total:** /70

Instructions

- There are 9 questions on 6 pages.
- Show your reasoning and calculations and always explain your answers.

Physical constants and useful formulae

$g = 9.80\,\mathrm{m/s^2}$

Question 1

At *one instant (first instant)* a mouse passes a piece of cheese while running left with speed 14.0 m/s. At *another instant (second instant)* 3.0 s later the mouse is still moving left but with a speed of 2.0 m/s. Determine the average acceleration of the mouse between the first and second instant.

2.0 m/s ← O ← 14 m/s O

$V_i = -14\,m/s$ $V_f = -2\,m/s$

$t_i = 0\,s$ $t_f = 3\,s$

+1 $a = \frac{\Delta V}{\Delta t} = \frac{V_f - V_i}{t_f - t_i}$

negative V positive accel (+1)

$= \frac{-2\,m/s - (-14\,m/s)}{3.0\,s} = \frac{-2\,m/s + 14\,m/s}{3.0\,s}$

$= \frac{12\,m/s}{3.0\,s} = 4.0\,m/s^2$

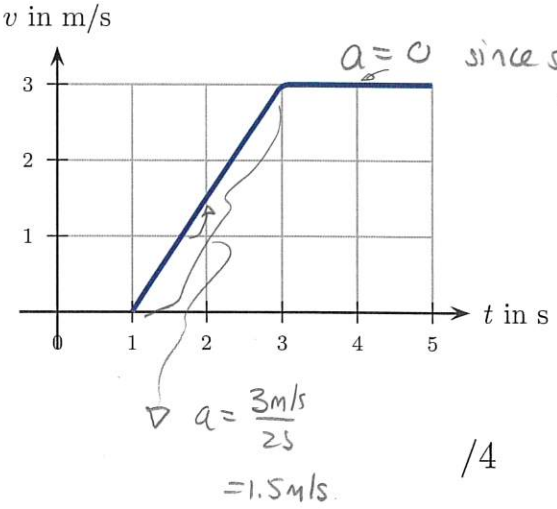
+4

/6

a = slope v vs t

Question 2

An ant walks along one direction and the graph of the ant's velocity vs. time is as illustrated. Which of the following (choose one) is true regarding the ant's acceleration?



a = 0 since slope = 0

a = 3m/s / 2s = 1.5m/s

i) Acceleration is larger at 4 s than at 2 s.

ii) Acceleration is smaller at 4 s than at 2 s.

iii) Acceleration is the same, but not zero, at 4 s as at 2 s.

iv) Acceleration is zero at 4 s and at 2 s.

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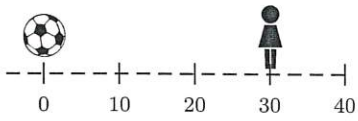
Question 3

A person runs left passing the 30 m mark toward a ball at the 0 m mark. The person runs at a constant speed, turns around at the ball and runs right passing the 30 m mark at the same speed and reaching it 6.0 s after she first passed it. Let a_{av} be the average acceleration from the moment she first passes the 30 m mark until she passes it again. Which of the following (choose one) is true?



i) $a_{av} = 0$

ii) a_{av} is positive.

iii) a_{av} is negative.

Earlier ← v_i negative

Later → v_f positive

$v_f - v_i$ = positive

⇒ a positive

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Question 4

A cat walks along a straight line. Its velocity is recorded at equally spaced intervals. According to the data in the table, is the acceleration of the cat constant or not? Explain your answer.

Time in s	Velocity in m/s
0.00	−0.60
0.10	−0.30
0.20	0.00
0.30	0.30
0.40	0.60
0.50	0.90
0.60	1.20

Velocity increases by 0.30 m/s every 0.10 s

⇒ accel = $\frac{\Delta v}{\Delta t} = \frac{0.30\,m/s}{0.10\,s}$

= 3.0 m/s

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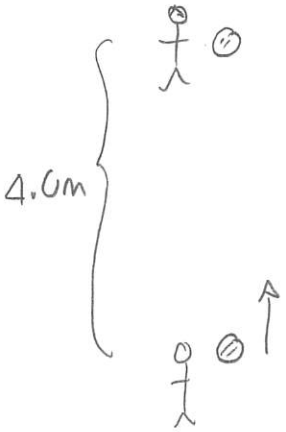
This is true for all intervals ⇒ a constant

Question 5

One construction worker standing on the ground throws a brick toward another worker standing above the ground on scaffolding. The worker on the ground throws the brick in such a way that its speed is exactly 0.0 m/s when it reaches the hand of the worker on the scaffolding. The brick travels vertically and the distance that it travels from the moment that it leaves the hand of the lower worker until it reaches the hand of the upper worker is exactly 4.0 m. Determine the speed with which the brick leaves the hand of the lower worker.



$t_i = 0s \quad t_f =$

$y_i = 0m \quad y_f = 4.0m$] +1

$v_i = ? \quad v_f = 0 m/s$] +1

$a_y = -g = -9.80 m/s^2$

+1

+2 actually used.

$v_f^2 = v_i^2 + 2a(y_f - y_i)$] +1

$(0 m/s)^2 = v_i^2 + 2(-9.80 m/s^2)(4.0m - 0.0m)$

$\Rightarrow 0 m^2/s^2 = v_i^2 - 78.4 m^2/s^2$] +4

$v_i^2 = 78.4 m^2/s^2 \Rightarrow v_i = \sqrt{78.4 m^2/s^2}$

$v_i = 8.9 m/s$] +2

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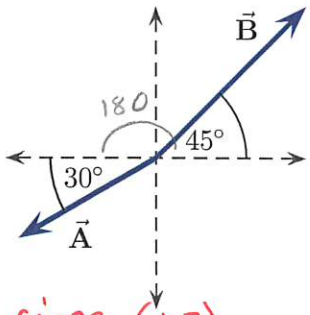
Question 6

Two displacement vectors are illustrated. The magnitude of $\vec{\mathbf{A}}$ is 50 m and that of $\vec{\mathbf{B}}$ is 100 m. Let $\vec{\mathbf{C}} = \vec{\mathbf{A}} + \vec{\mathbf{B}}$.



a) Determine the components of $\vec{\mathbf{C}}$ and the magnitude of $\vec{\mathbf{C}}$.

$A_x = A\cos\theta = 50\text{m}\cos(210°)$

$= -43\text{m}$

$A_y = A\sin\theta = 50\text{m}\sin(210°)$

$= -25\text{m}$

minus signs (+2)

magnitudes (+3)

$B_x = B\cos\theta = 100\text{m}\cos(45°)$

$= 71\text{m}$

$B_y = B\sin\theta = 100\text{m}\sin(45°)$

$= 71\text{m}$

magnitudes (+3)

$C_x = A_x + B_x = -43\text{m} + 71\text{m} = 28\text{m}$

$C_y = A_y + B_y = -25\text{m} + 71\text{m} = 46\text{m}$

$C_x = 28\text{m}$, $C_y = 46\text{m}$ (+2)

$C = \sqrt{C_x^2 + C_y^2} = \sqrt{(28\text{m})^2 + (46\text{m})^2} = 54\text{m}$ (+2)

b) Is it possible to find any number α so that $\vec{\mathbf{B}} = \alpha\vec{\mathbf{A}}$? Explain your answer.

(+1) No. This is only possible if $\vec{B}$ and $\vec{A}$ are same directions or exactly opposite. They are not.

reason (+1)

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Question 7

Various bugs wanders around on a flat horizontal table. Each moves at a constant speed. Some move in straight lines without changing direction, and others move along curved paths. Which of the following (choose one) is true?

i) The acceleration of every one of these bugs must be zero.

ii) The acceleration of every one of these bugs must be non-zero.

(iii) Some bugs have zero acceleration, others have non-zero acceleration.

Briefly explain your answer.

The bugs moving along curved paths change direction ⇒ velocity changes
⇒ accel ≠ 0

The bugs moving along straight lines ⇒ velocity constant
⇒ accel = 0.

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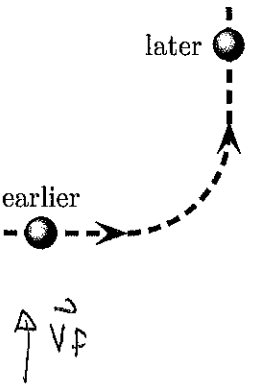
Question 8

An asteroid passes a (hidden) planet and its trajectory is as illustrated. It's locations at two instants are as illustrated and, at these instants it has the same speed. Which of the following is true regarding its average acceleration from the earlier to the later instant?



i) $\vec{\mathbf{a}} = 0$

ii) $\vec{\mathbf{a}} \neq 0$, pointing ↑

iii) $\vec{\mathbf{a}} \neq 0$, pointing ↓

iv) $\vec{\mathbf{a}} \neq 0$, pointing ↗

(v) $\vec{\mathbf{a}} \neq 0$, pointing ↖

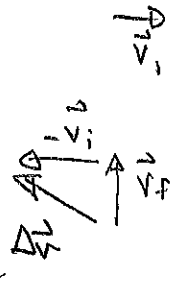
vi) $\vec{\mathbf{a}} \neq 0$, pointing ↘

vii) $\vec{\mathbf{a}} \neq 0$, pointing ↙

Explain your choice.

$\vec{a} = \frac{\Delta \vec{v}}{\Delta t}$

$= \frac{\vec{v}_f - \vec{v}_i}{\Delta t}$



same as direction of $\vec{a}$

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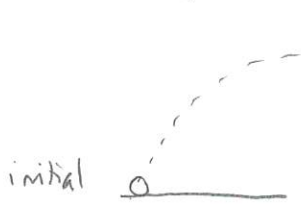
Question 9

A bug jumps from the ground with a speed of 5.0 m/s; the bug leaves the ground at an angle of 60° from the ground. Ignore air resistance in this problem.

a) Determine the highest point reached by the bug above the ground.



$t_i = 0s$ $\quad t_f =$

$x_i = 0m$ $\quad x_f =$

$y_i = 0m$ $\quad y_f =$

$V_{ix} = 2.5 m/s$ $\quad V_{fx} =$

$V_{iy} = 4.3 m/s$ $\quad V_{fy} = 0$ (+1)

$a_x = 0 m/s^2$ $\quad a_y = -9.8 m/s^2$ (+1)

$\vec{V_f}$ → $\Rightarrow V_{fy} = 0$

$V_{ix} = V_i \cos 60^\circ$ (+1)

$= 5.0 m/s \cos 60^\circ$

$= 2.5 m/s$

$V_{iy} = V_i \sin 60^\circ = 5.0 m/s \sin 60^\circ$ (+2)

(+1) $= 4.3 m/s$

Need y_f (+1)

$V_{fy}^2 = V_{iy}^2 + 2a_y(y_f - y_i)$ (+1)

$(0 m/s)^2 = (4.3 m/s)^2 + 2(-9.80 m/s^2)(y_f - 0m)$

$0 m^2/s^2 = 18.75 m^2/s^2 - 19.6 m/s^2 \, y_f$

$\Rightarrow 19.6 m/s^2 \, y_f = 18.75 m^2/s^2$

$\Rightarrow y_f = \dfrac{18.75 m^2/s^2}{19.6 m/s^2} = 0.96 m$ +3

b) Determine the speed of the bug at its highest point.

$V_{fy} = 0 m/s$ $\quad V_{fx} = V_{ix} + \cancel{a_x \Delta t}^{\,0}$ (+1) $\Rightarrow V_{fx} = 2.5 m/s$ (+2)

So speed $= 2.5 m/s$

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