first (given)	last (family)	Physics 2211 AB Fall 2019	Nine-digit Tech ID

Name, *printed* as it appears in Canvas

Quiz

1A

- **Print** your name and nine-digit Tech ID *very neatly* in the spaces above.
- Free-response problems are numbered I–III. Show all your work clearly, including all steps and logic. Write **darkly**. Blue or black ink is recommended. Do not make any erasures in your free-response work. Cross out anything you do not want evaluated. Box your answer.
- Multiple-choice questions are numbered 1–7. For each, select the answer most nearly correct, circle it on your quiz, and fill the bubble for your answer on this front page.
- Initial the odd pages in the top margin, in case the pages of your quiz get separated.
- The standard formula sheet is on the back of this page, which may be removed from the quiz form if you wish, but it must be submitted.
- If the page for a free-response problem has insufficient space for your work, ask a proctor for an additional sheet. If you wish this work to be evaluated, put your name on the sheet and make a note on the problem page, so graders will know where to look for your work.
- You may use a calculator that cannot store letters, but no other aids or electronic devices.
- Your score will be posted when your quiz has been graded. Quiz grades become final after the first Reading Day, Wednesday, April 24.

Fill in bubbles for your Multiple Choice answers darkly and neatly.

	a	b	c	d	e
1	ⓐ	ⓑ	ⓒ	ⓓ	ⓔ
2	ⓐ	ⓑ	ⓒ	ⓓ	ⓔ
3	ⓐ	ⓑ	ⓒ	ⓓ	ⓔ
4	ⓐ	ⓑ	ⓒ	ⓓ	ⓔ
5	ⓐ	ⓑ	ⓒ	ⓓ	ⓔ
6	ⓐ	ⓑ	ⓒ	ⓓ	ⓔ
7	ⓐ	ⓑ	ⓒ	ⓓ	ⓔ
	a	b	c	d	e

Quiz and Exam Formulæ & Constants

$$\vec{v} = \frac{d\vec{r}}{dt}$$
$$\vec{\omega} = \frac{d\vec{\theta}}{dt}$$
$$\vec{a} = \frac{d\vec{v}}{dt}$$
$$\vec{\alpha} = \frac{d\vec{\omega}}{dt}$$
$$v_{\text{sf}} = v_{\text{si}} + a_{\text{s}}\,\Delta t$$
$$\omega_{\text{f}} = \omega_{\text{i}} + \alpha\,\Delta t$$
$$s_{\text{f}} = s_{\text{i}} + v_{\text{si}}\,\Delta t + \tfrac{1}{2}a_{\text{s}}\,(\Delta t)^2$$
$$\theta_{\text{f}} = \theta_{\text{i}} + \omega_{\text{si}}\,\Delta t + \tfrac{1}{2}\alpha\,(\Delta t)^2$$
$$s = r\theta$$
$$v = r\omega$$
$$a_{\text{t}} = r\alpha$$

$$\sum \vec{F} = m\vec{a} = \frac{d\vec{p}}{dt}$$
$$\sum \vec{F}_{\text{ext}} = M\vec{a}_{\text{cm}} = \frac{d\vec{P}}{dt}$$
$$\sum \vec{\tau}_{\text{ext}} = I\vec{\alpha} = \frac{d\vec{L}}{dt}$$
$$f_{\text{s,max}} = \mu_{\text{s}} n$$
$$f_{\text{k}} = \mu_{\text{k}} n$$
$$a_{\text{r}} = \frac{v^2}{r}$$
$$\vec{w} = m\vec{g}$$
$$|\vec{F}_{\text{G}}| = \frac{Gm_1m_2}{|\vec{r}|^2}$$
$$D = \tfrac{1}{2}C\rho A v^2$$
$$\vec{\tau} = \vec{r} \times \vec{F}$$

$$W = \int \vec{F} \cdot d\vec{s}$$
$$W_{\text{ext}} = \Delta K + \Delta U + \Delta E_{\text{th}}$$
$$K = \tfrac{1}{2}mv^2$$
$$K = \tfrac{1}{2}I\omega^2$$
$$U_{\text{g}} = mgy$$
$$U_{\text{s}} = \tfrac{1}{2}k\,(\Delta s)^2$$
$$U_{\text{G}} = -\frac{Gm_1m_2}{r}$$
$$P = \frac{dE_{\text{sys}}}{dt}$$
$$P = \vec{F} \cdot \vec{v}$$
$$\vec{J} = \int \vec{F}\,dt = \Delta\vec{p}$$
$$\vec{p} = m\vec{v}$$

$$\vec{r}_{\text{cm}} = \frac{\sum \vec{r}_i m_i}{\sum m_i}$$
$$\vec{r}_{\text{cm}} = \frac{\int \vec{r}\,dm}{\int dm}$$
$$I = \sum m_i r_i^2$$
$$I = \int r^2\,dm$$
$$I = I_{\text{cm}} + Md^2$$
$$\vec{L} = \vec{r} \times \vec{p}$$
$$\vec{L} = I\vec{\omega}$$
$$x = A\cos(\omega t + \phi_0)$$
$$\vec{a}_{\text{x}} = -\omega^2\vec{x}$$
$$\omega = \sqrt{k/m}$$
$$\omega = 2\pi f = \frac{2\pi}{T}$$

Physical Constants:

Universal Gravitation Constant $G = 6.673 \times 10^{-11}\,\text{N}\cdot\text{m}^2/\text{kg}^2$
Gravitational Acceleration at Earth's Surface $g = 9.81\,\text{m/s}^2$

Unless otherwise directed, drag is to be neglected and all problems take place on Earth.
All derivatives and integrals in free-response problems must be evaluated.

You may remove this sheet from your Quiz or Exam

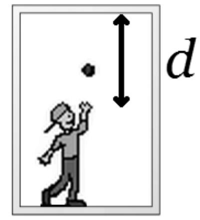
Initial:

I. (16 points) An object is subject to acceleration in one dimension of the form

$$a(t) = a_0 \cos(\omega t)$$

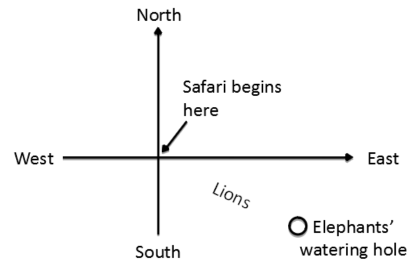
where a_0 and ω are positive constants. At time $t = 0$ the object is found at the origin with a velocity of zero. Calculate the next time at which velocity of the object is zero. Express your answer in terms of parameters defined in the problem and physical or mathematical constants.

II. (16 points) Inside a large crate, Billy throws a ball straight upward. It hits the top of the crate with a speed v_f at a distance d above his hand. How much time was required for the ball to travel from Billy's hand to the top of the crate? Express your answer in terms of parameters defined in the problem and physical or mathematical constants. *On Earth.*



1. (6 points) In the problem above, consider what happens if Billy simply drops the rock, rather than throwing it upward. Compare the acceleration of the rock shortly after leaving Billy's hand when dropped, to the acceleration when he throws it upward.
   (a) When dropped, the rock has a greater acceleration magnitude than when it is thrown upward, in the opposite direction.
   (b) When dropped, the rock has the same acceleration magnitude as when it is thrown upward, in the same direction.
   (c) When dropped, the rock has a lesser acceleration magnitude than when it is thrown upward, in the opposite direction.
   (d) When dropped, the rock has the same acceleration magnitude as when it is thrown upward, but in the opposite direction.
   (e) When dropped, the rock has a greater acceleration magnitude than when it is thrown upward, in the same direction.

III. (16 points) You are on a safari on the Kalahari, with the ambition of watching elephants. The best place to watch elephants is on their watering hole, 10 kilometers and 30° south of east from your current location. However, to avoid lions between the starting point and the watering hole, you decide to walk 15° north of east for 90 minutes at a speed of 5 kilometers per hour. After taking this detour, what distance and direction must you walk to reach the watering hole? Provide the direction as an angle with respect to the East.



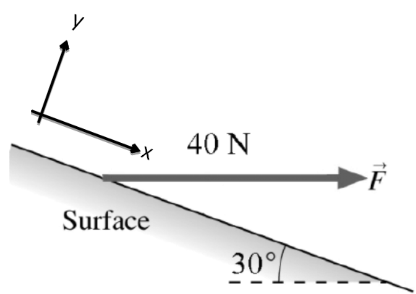
2. (6 points) On the return trip, you walk directly west until you are exactly south of the starting point and then north, until you are back on the safari starting point. What distance did you walk in total on the way back?
   (a) 28.3 km
   (b) 10 km
   (c) 14.6 km
   (d) 13.7 km
   (e) 7.1 km

3. (8 points) A train and a car are traveling parallel to each other at constant velocity $\vec{v}_0$. At t=0, the car slows down with acceleration magnitude a, while the train continues to travel with constant velocity. As soon as the car reaches speed $v = 0$ it begins to speed up, in the same direction as before, with acceleration magnitude a. By the time that the car reaches velocity $\vec{v}_0$ again, what is the ratio D_t/D_c of the distance covered by the train by the distance covered by the car? *Hint:* This problem is most easily solved graphically.

   (a) $D_t/D_c = 4$
   (b) $D_t/D_c = v_0^2/a$
   (c) $D_t/D_c = 2$
   (d) $D_t/D_c = v_0^2/2a$
   (e) $D_t/D_c = 1/4$

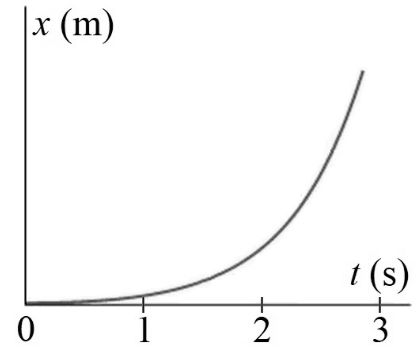
4. (8 points) Using the coordinate system shown, which is the correct expression for the force vector $\vec{F}$?

   (a) $40\hat{\imath}\,\mathrm{N}$
   (b) $20\hat{\imath} + 35\hat{\jmath}\,\mathrm{N}$
   (c) $35\hat{\imath} + 20\hat{\jmath}\,\mathrm{N}$
   (d) $-23\hat{\imath} + 20\hat{\jmath}\,\mathrm{N}$
   (e) $35\hat{\imath} - 20\hat{\jmath}\,\mathrm{N}$



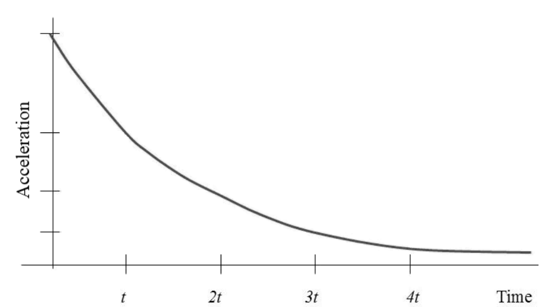
5. (8 points) The graph shows the position of an object moving along the x axis as a function of time t. At what time, if any, in the graphed range is the instantaneous velocity equal to the average velocity over the entire range?

(a) near time $t = 2\,\mathrm{s}$
(b) at then end, near time $t = 3\,\mathrm{s}$
(c) at the beginning, near time $t = 0\,\mathrm{s}$
(d) near time $t = 1\,\mathrm{s}$
(e) at no time in the graphed range



6. (8 points) Two objects, A and B, are traveling in the positive direction. Object A has constant positive velocity. Object B has positive velocity and a positive acceleration that decays exponentially with time, as shown. Object B passes object A at time t. How does the distance between the objects change with time after that?

(a) The distance between A and B increases then decreases, but eventually B remains ahead of A by an ever-decreasing amount.
(b) The distance between A and B increases then decreases, and eventually B remains ahead of A by a constant amount.
(c) The distance between A and B increases then remains the same, so eventually B remains ahead of A by a constant amount.
(d) The distance between A and B increases then decreases, and eventually A passes B.
(e) The distance between A and B always increases, so B is always ahead of A by an ever-increasing amount.



7. (8 points) A train slows as it approaches a train station from the right. The station is at the origin, and the positive direction is toward the right, as shown. Unfortunately, the train overshoots the station, and comes to a stop to the left of the station. It then speeds up in reverse, to approach the station from the left. What is the sign of the train's acceleration as it approaches the station, first from the right, and then from the left.

(a) Acceleration is positive approaching from the right, and negative approaching from the left.
(b) Acceleration is negative approaching from the right, and positive approaching from the left.
(c) Acceleration is negative approaching from the right, and negative approaching from the left.
(d) Acceleration is positive approaching from the right, and positive approaching from the left.