| first (given) | last (family) | **Physics 2211 A** | Nine-digit Tech ID |
|---|---|---|---|
| Name, *printed* as it appears in Canvas | | Fall 2020 | |

Quiz
# 1A

- You may use the standard formula sheet and a calculator that cannot store letters, but no other aids or electronic devices.
- Free-response problems require a file upload. 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. Check your scan to make sure it is clear, and upload it to Gradescope. *Do not scan and upload this cover page.*
- Multiple-choice questions must be answered directly in Gradescope.
- Your score will be posted when your quiz has been graded. Quiz grades become final when the next quiz is administered.

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*Select your Multiple Choice answers directly in Gradescope.*

$$\vec{v} = \frac{d\vec{r}}{dt}$$

$$\vec{\omega} = \frac{d\vec{\theta}}{dt}$$

$$\vec{a} = \frac{d\vec{v}}{dt}$$

$$\vec{\alpha} = \frac{d\vec{\omega}}{dt}$$

$$v_{\mathrm{sf}} = v_{\mathrm{si}} + a_{\mathrm{s}}\,\Delta t$$

$$\omega_{\mathrm{f}} = \omega_{\mathrm{i}} + \alpha\,\Delta t$$

$$s_{\mathrm{f}} = s_{\mathrm{i}} + v_{\mathrm{si}}\,\Delta t + \tfrac{1}{2}a_{\mathrm{s}}\,(\Delta t)^2$$

$$\theta_{\mathrm{f}} = \theta_{\mathrm{i}} + \omega_{\mathrm{si}}\,\Delta t + \tfrac{1}{2}\alpha\,(\Delta t)^2$$

$$s = r\theta$$

$$v = r\omega$$

$$a_{\mathrm{t}} = r\alpha$$

$$\sum \vec{F} = m\vec{a} = \frac{d\vec{p}}{dt}$$

$$\sum \vec{F}_{\mathrm{ext}} = M\vec{a}_{\mathrm{cm}} = \frac{d\vec{P}}{dt}$$

$$\sum \vec{\tau}_{\mathrm{ext}} = I\vec{\alpha} = \frac{d\vec{L}}{dt}$$

$$f_{\mathrm{s,max}} = \mu_{\mathrm{s}} n$$

$$f_{\mathrm{k}} = \mu_{\mathrm{k}} n$$

$$a_{\mathrm{r}} = \frac{v^2}{r}$$

$$\vec{w} = m\vec{g}$$

$$|\vec{F}_{\mathrm{G}}| = \frac{Gm_1m_2}{|\vec{r}|^2}$$

$$D = \tfrac{1}{2}C\rho A v^2$$

$$\vec{\tau} = \vec{r} \times \vec{F}$$

$$W = \int \vec{F} \cdot d\vec{s}$$

$$W_{\mathrm{ext}} = \Delta K + \Delta U + \Delta E_{\mathrm{th}}$$

$$K = \tfrac{1}{2}mv^2$$

$$K = \tfrac{1}{2}I\omega^2$$

$$U_{\mathrm{g}} = mgy$$

$$U_{\mathrm{s}} = \tfrac{1}{2}k\,(\Delta s)^2$$

$$U_{\mathrm{G}} = -\frac{Gm_1m_2}{r}$$

$$P = \frac{dE_{\mathrm{sys}}}{dt}$$

$$P = \vec{F} \cdot \vec{v}$$

$$\vec{J} = \int \vec{F}\,dt = \Delta\vec{p}$$

$$\vec{p} = m\vec{v}$$

$$\vec{r}_{\mathrm{cm}} = \frac{\sum \vec{r}_i m_i}{\sum m_i}$$

$$\vec{r}_{\mathrm{cm}} = \frac{\int \vec{r}\,dm}{\int dm}$$

$$I = \sum m_i r_i^2$$

$$I = \int r^2\,dm$$

$$I = I_{\mathrm{cm}} + Md^2$$

$$\vec{L} = \vec{r} \times \vec{p}$$

$$\vec{L} = I\vec{\omega}$$

$$x = A\cos(\omega t + \phi_0)$$

$$\vec{a}_{\mathrm{x}} = -\omega^2\vec{x}$$

$$\omega = \sqrt{k/m}$$

$$\omega = 2\pi f = \frac{2\pi}{T}$$

Physical Constants:

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

*Unless otherwise directed, drag is to be neglected, all problems take place on Earth, use the gravitational definition of weight, and all springs, ropes, and pulleys are ideal. All derivatives and integrals in free-response problems must be evaluated.*

Initial:

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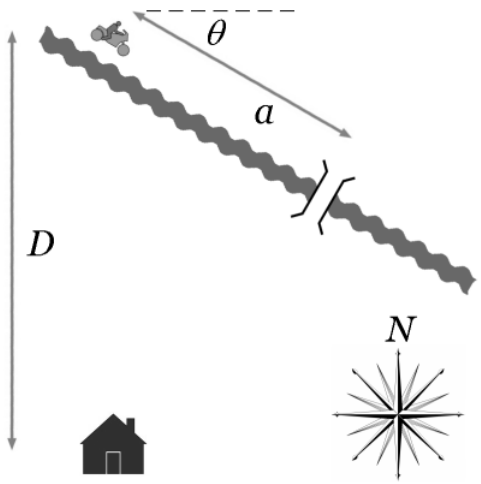
*I*. (16 points) A car is travelling in a straight line with velocity $+v_0$. At time $t = 0$, it begins to accelerate at $a = +k\sqrt{t}$, where $k$ is a positive constant. Through what distance does the car travel between times $t = 0$ and $t = T$? Express this distance in terms of any or all of $v_0$, $k$, $T$, and physical or mathematical constants.

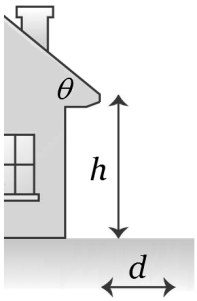
*II*. (16 points) You are motorcycling home, when you find your way blocked by a swollen stream. At that instant, you are directly north of your home, and a distance $D = 19\,\text{km}$ away, as illustrated. You travel a distance $a = 11\,\text{km}$ along the stream, in a direction $\theta = 54°$ south of east, to a bridge. How far from your home are you now? (The bridge has negligible length, so it does not matter which side you are on.)




1. (6 points) In what direction should you travel to get to your home from the bridge? Let the positive East axis be zero, with positive angles toward the North.

   (a) 57° (b) 306° (c) 237° (d) 33° (e) 147°

*III*. Santa Claus (not shown) steps out of the chimney and slides down the icy roof that makes an angle $\theta$ with the horizontal. He leaves the roof with a speed $v_0$, and lands a horizontal distance $d$ from that point. What is the height, $h$, from which he fell? Express your answer in terms of parameters defined in the problem, and physical or mathematical constants. (*On Earth.*)

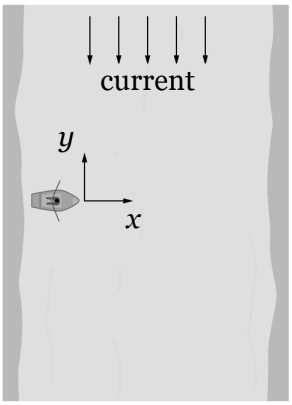



2. (6 points) In the problem above, Santa Claus is traveling at an angle $\phi$ below the horizontal at the instant he lands on the ground. If it can be determined, how does this angle compare to the roof angle $\theta$?

   (a) $90^\circ > \phi > \theta$
   (b) $0^\circ < \phi < \theta$
   (c) The relationship between $\phi$ and $\theta$ cannot be determined from the information provided.
   (d) $\phi = \theta$
   (e) $\phi = 90^\circ$

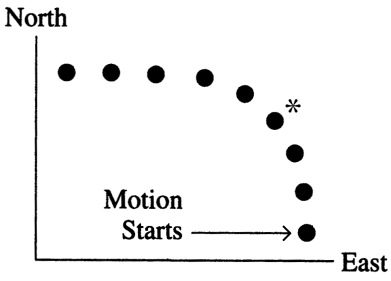
3. (8 points) Mary needs to row her boat across a 100 m wide river that flows in the $-y$ direction at 1 m/s. Mary can row a a speed of 2 m/s. Assume that Mary wants to land directly across the river (i.e., in the $+x$ direction) from the point at which she started. In which direction must she point her boat with respect to the $x$ axis?

(a) $\cos^{-1}(\sqrt{3}/2)$
(b) $\cos^{-1}(2/\sqrt{5})$
(c) $\cos^{-1}(1/\sqrt{5})$
(d) $\cos^{-1}(1/\sqrt{3})$
(e) $\cos^{-1}(2/3)$

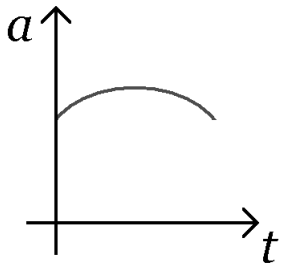



4. (8 points) Consider the motion diagram of an object moving at constant speed. It is initially traveling North, then turns to travel West. What is the direction, if any, of the object's acceleration when it is halfway around the turn, at the frame marked with an asterisk?

(a) The acceleration is non-zero to the northeast.
(b) The acceleration is non-zero to the west.
(c) The acceleration is non-zero to the northwest.
(d) The acceleration is zero, so it has no direction.
(e) The acceleration is non-zero to the southwest.



5. (8 points) The graph shows the acceleration of an object moving in a straight line as a function of time. The velocity of the object is positive at time $t = 0$. During the time represented on the graph, the speed of this object ...

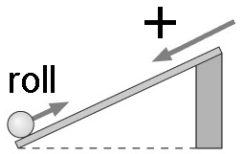


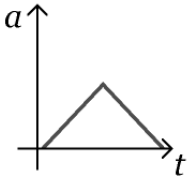

(a) remains constant.
(b) decreases then increases.
(c) increases.
(d) decreases.
(e) increases then decreases.

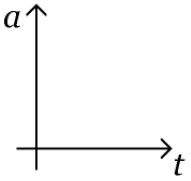
6. (8 points) Consider two vectors, $\vec{A}$ and $\vec{B}$. Let their sum be $\vec{S} = \vec{A} + \vec{B}$ and their difference be $\vec{D} = \vec{A} - \vec{B}$. How must the *magnitudes* of $\vec{S}$ and $\vec{D}$ be related?

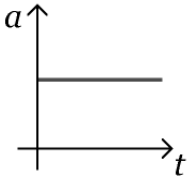
(a) $|\vec{S}| > |\vec{D}|$ (b) None of the others is correct. (c) $|\vec{S}| < |\vec{D}|$ (d) $|\vec{S}| = -|\vec{D}|$ (e) $|\vec{S}| = |\vec{D}|$

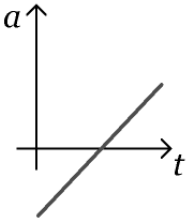
7. (8 points) The ball rolls up the ramp, then back down. The positive direction has been defined as down the ramp. Which is the appropriate graph of acceleration vs. time? (*On Earth.*)




(a)



(b)



(c)



(d)



(e)