first (given)	last (family)

Name, *printed* as it appears in Canvas

Physics 2211 AB

Fall 2019

Nine-digit Tech ID

Quiz

3A

- **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 when the next quiz is administered.

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

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

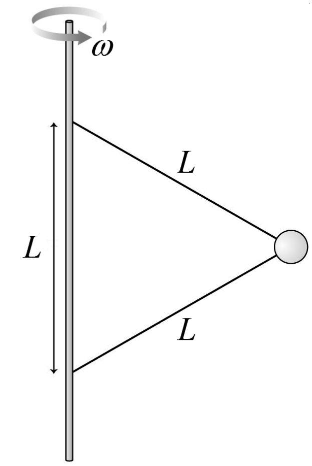
Universal Gravitation Constant $G = 6.673 \times 10^{-11}\,\text{N}\cdot\text{m}^2/\text{kg}^2$
Gravitational Acceleration at Earth's Surface $g = 9.81\,\text{m/s}^2$

Unless otherwise directed, drag is to be neglected, 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.

You may remove this sheet from your Quiz or Exam, but it must be submitted

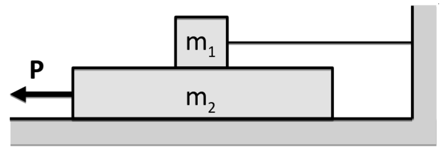
I. (16 points) Asteroids have a density of $2500\,\mathrm{kg/m^3}$ (this is also the typical density of rocks on Earth). An Olympian can run at $10.0\,\mathrm{m/s}$. What's the maximum radius of a spherical asteroid, so that the Olympian can get into orbit just by running?

II. (16 points) Two strings, each of length $L = 1.5\,\mathrm{m}$ tie a sphere to a rotating shaft, as shown, so the sphere revolves in a horizontal circle. If the tension in the upper string is *twice* the tension in the lower string, with what constant angular speed ω is the shaft rotating? (*On Earth.*)



1. (6 points) If the sphere in the problem above has mass m and the tensions in the upper and lower strings are T and $T/2$, respectively, what is the apparent weight of the sphere as it revolves?
   (a) Zero
   (b) $3T/2$
   (c) $\sqrt{[(3T/2)\cos 30°]^2 + [(T/2)\sin 30°]^2} - mg$
   (d) $\sqrt{[(3T/2)\cos 30°]^2 + [(T/2)\sin 30°]^2}$
   (e) $(3T/2) - mg$

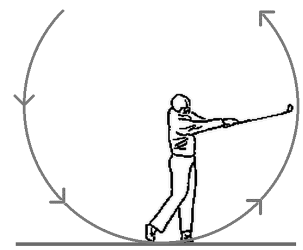
III. (16 points) A block of mass m_1 rests on top of a block of mass m_2. There is friction on all surfaces with coefficient of static friction μ_s and coefficient of kinetic friction μ_k. A force $\vec{P}$ pulls on the lower box as shown. Calculate the magnitude of the force P such that the box of mass m_2 moves with constant speed in terms of parameters defined in the problem, and physical or mathematical constants. (*On Earth.*)



2. (6 points) If the magnitude of force $\vec{P}$ were small enough in the above problem, neither the upper nor lower block would move. In that situation, what is the magnitude of the static friction force acting on the *upper* block?

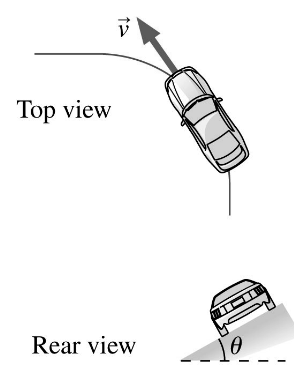
   (a) $\mu_s (m_1 + m_2) g$
   (b) $\mu_s m_2 g$
   (c) It has the same magnitude as the tension in the string.
   (d) Zero.
   (e) It has the same magnitude as the pulling force $\vec{P}$.

3. (8 points) A golfer swings his club in a vertical circle, hitting the ball to the right at the bottom of the swing. As he follows through, the club rises and slows. In what direction is the acceleration of the club's head at the moment shown? (*On Earth.*)



(a) Straight down.
(b) Straight up.
(c) Toward a point above the golfer's head.
(d) Approximately toward the golfer's feet.
(e) Approximately toward the golfer's shoulders.

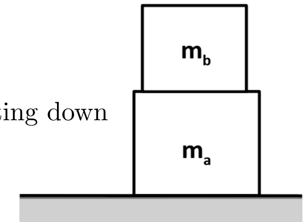
4. (8 points) The car rounds the banked curve at the maximum speed it can do so without sliding. Given that there is a frictional force between the tires and the road surface, which of these are forces on the car with a non-zero component in the direction of its acceleration? (*On Earth.*)



i. The centripetal force
ii. The gravitational force
iii. The frictional force
iv. The normal force

(a) Just *iii*.
(b) Just *i* and *ii*.
(c) Just *i*.
(d) Just *i*, *iii*, and *iv*.
(e) Just *iii* and *iv*.

5. (8 points) There is a normal force, pointing up, that the Earth exerts on bottom block "a". What is the other force in the action-reaction pair with this force? *(On Earth.)*



   (a) The weight of top block "b", $m_b g$, pointing up
   (b) A normal force that top block "b" exerts on block "a", pointing down
   (c) The weight of block "a", $m_a g$, pointing down
   (d) The weight of block "a" plus the weight of top block "b", $(m_a + m_b)\,g$, pointing down
   (e) A normal force that block "a" exerts on the Earth, pointing down

6. (8 points) Europa is one of Jupiter's moons. It has 1/124 the mass of the Earth and its radius is 1/4 that of the Earth. With this information, and remembering that the free fall acceleration at the Earth's surface is $9.8\,\mathrm{m/s^2}$, calculate the free fall acceleration on the surface of Europa.

   (a) $0.08\,\mathrm{m/s^2}$
   (b) $9.8\,\mathrm{m/s^2}$
   (c) $2.9\,\mathrm{m/s^2}$
   (d) $1.3\,\mathrm{m/s^2}$
   (e) $0.32\,\mathrm{m/s^2}$

7. (8 points) Jorge is wearing his frictionless roller skates, and pulling on a rope. He has passed this rope around a pulley attached to the wall, then around another pulley tied to his waist, and then fastened it to the wall, as shown. If Jorge has mass m, and pulls with force magnitude F, what is the magnitude of his acceleration a across the level floor? You may assume that the rope is horizontal where it is not passing around a pulley. *(On Earth.)*

(a) $a = 2F/m$
(b) $a = F/(3m)$
(c) $a = F/m$
(d) $a = F/(2m)$
(e) $a = 3F/m$