first (given)	*last (family)*	Nine-digit Tech ID

Name, *printed* as it appears in Canvas

Physics 2211 AB

Fall 2019

Quiz

4A

- **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

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

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

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

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

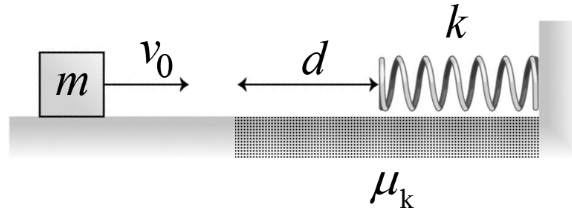
Physical Constants:

Universal Gravitation Constant $G = 6.673\times10^{-11}\,\mathrm{N{\cdot}m^2/kg^2}$
Gravitational Acceleration at Earth's Surface $g = 9.81\,\mathrm{m/s^2}$

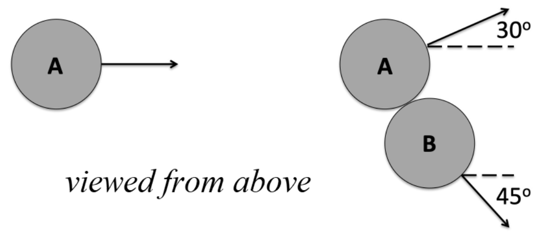
Unless otherwise directed, drag is to be neglected, all problems take place on Earth, use the gravitational definition of weight, and all springs, ropes, and pulleys are ideal.
All derivatives and integrals in free-response problems must be evaluated.

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

I. (16 points) A block of mass $m = 3.3\,\text{kg}$ is sliding at speed $v_0 = 6.6\,\text{m/s}$ on a frictionless level surface. It then enters a region in which the coefficient of kinetic friction between the block and the surface is $\mu_k = 0.11$. After sliding a distance $d = 0.55\,\text{m}$ in this region, it encounters a spring with Hooke's Law constant $k = 88\,\text{N/m}$. What is the maximum compression of the spring? (*On Earth.* Note that friction between the block and the surface continues after the block hits the spring!)



1. (6 points)An air hockey puck (A) of mass m is moving along the x-axis with speed v_0 when it hits an identical stationary puck (B). Puck A changes direction to move 30° above the x-axis and puck (B) moves 45° below the x-axis. Just with the information provided, and without any calculations, which statement do you know must be *incorrect*?



   (a) The collision is perfectly inelastic.
   (b) The momentum of the system of two pucks is conserved.
   (c) During the collision puck B delivers impulse to puck A.
   (d) Energy, including mechanical and other types of energy, is conserved.
   (e) The momentum of puck B is not conserved.

II. (16 points) In the problem above, find the final speed of puck A. Express your answer in terms of m and v_0.

III. (16 points) An object is resting on a frictionless surface and is subject to the following force:

$$\vec{F} = Ay\cos\left(\frac{\pi x}{B}\right)\hat{\imath} + Ax\sin\left(\frac{\pi y}{B}\right)\hat{\jmath}$$

where $A = 1.0\,\mathrm{N/m}$ and $B = 1.0\,\mathrm{m}$. The object may move from the origin to $(1.0\,\mathrm{m},\ 1.0\,\mathrm{m})$ by one of two paths:

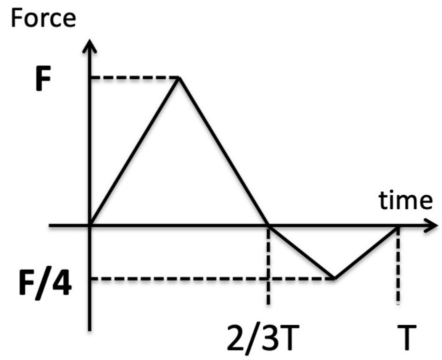
Path a: Origin to $(1.0\,\mathrm{m},\ 0.0\,\mathrm{m})$, then $(1.0\,\mathrm{m},\ 0.0\,\mathrm{m})$ to $(1.0\,\mathrm{m},\ 1.0\,\mathrm{m})$
Path b: Origin to $(0.0\,\mathrm{m},\ 1.0\,\mathrm{m})$, then $(0.0\,\mathrm{m},\ 1.0\,\mathrm{m})$ to $(1.0\,\mathrm{m},\ 1.0\,\mathrm{m})$

If the object follows path b, the force does zero work on the object. Calculate the work done by the force on the object if it follows path a.

2. (6 points) The work along path a above is different than that of path b. What is true about this force?
   (a) With the given information it's not possible to determine if the force is conservative or not.
   (b) This force is conservative, because it's possible to build an isolated system in which energy is conserved.
   (c) This force is not conservative, because there are two paths along which the work differs.
   (d) The force is not conservative because only friction is not conservative.
   (e) This force may be conservative, if there is another path for which work matches that along a, and yet another path that matches the work along b.

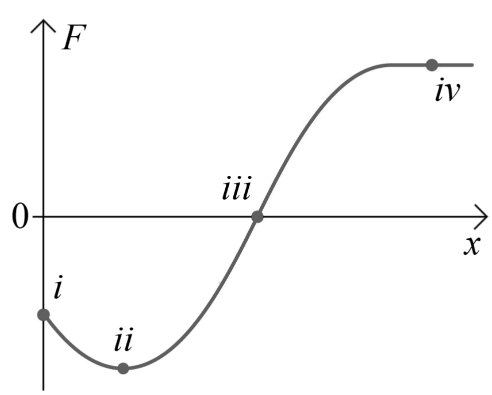
3. (8 points) An object is subject to the time-varying force shown. Calculate the average force on the object over a time T.

   (a) $3F/4$
   (b) $F/2$
   (c) $9F/24$
   (d) $7F/24$
   (e) F



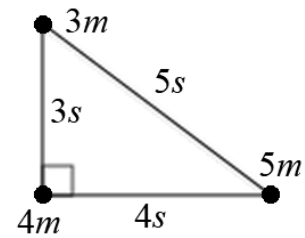
4. (8 points) A particle in a system has a force $\vec{F}$ exerted on it, that depends on the position x of the particle. Four possible positions of the particle are indicated on the graph. Of those four positions, which results in the system having maximum potential energy?

   (a) The system has maximum potential energy when the particle is at position i.
   (b) The system has maximum potential energy when the particle is at position iii.
   (c) It cannot be determined when the system has maximum potential energy unless the zero point for potential energy is known.
   (d) The system has maximum potential energy when the particle is at position ii.
   (e) The system has maximum potential energy when the particle is at position iv.



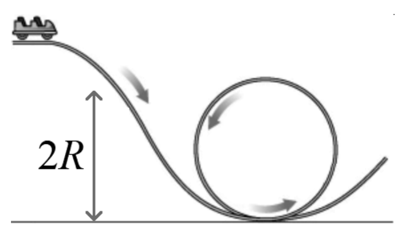
Initial:

5. (8 points) A system consists of three point masses with masses $3m$, $4m$, and $5m$ on the vertexes of a 3-4-5 right triangle with sides $3s$, $4s$, and $5s$, as shown. How much work must an external agent do to disassemble the system, moving the point masses to infinite separation?



(a) $-60Gm^2/s$
(b) $+60Gm^2/s$
(c) $+12Gm^2/s$
(d) $-12Gm^2/s$
(e) $-Gm^2/s$

6. (8 points) The roller-coaster in the illustration is truly a "coaster" — the car speeds up as it descends on its frictionless track, and slows down again as it ascends. If the care is released from rest, from what height h **must** the it start to successfully complete the loop? *(On Earth.)*



(a) From *some* heights h less than $2R$.
(b) From *some* heights h greater than $2R$.
(c) From height $h = 2R$ and *any* heights h greater than $2R$.
(d) From *any* heights h less than $2R$.
(e) From *any* heights h greater than $2R$.

7. (8 points) A truck of mass M is moving with speed V. A tennis ball, mass m, traveling in the opposite direction with speed v, hits the front of the truck head-on. What will be the velocity of the ball after the collision? Assume that the mass of the truck is much larger than that of the tennis ball ($M \gg m$).

(a) The ball will be moving in the opposite direction of the truck with speed $V + v$
(b) The ball will be moving in the same direction of the truck with speed $2V - v$
(c) The ball will be moving in the same direction of the truck with speed $2V + v$
(d) The ball will come to a rest
(e) The ball will be moving in the opposite direction of the truck with speed $V - v$