first (given)	last (family)

Name, *printed* as it appears in Canvas

Physics 2211 A

Spring 2021

Nine-digit Tech ID

Quiz

4A

- 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 after the first Reading Day, Wednesday, April 28.

Select your Multiple Choice answers directly in Gradescope.

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

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

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

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

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

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

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

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

$$s = r\theta$$

$$v = r\omega$$

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

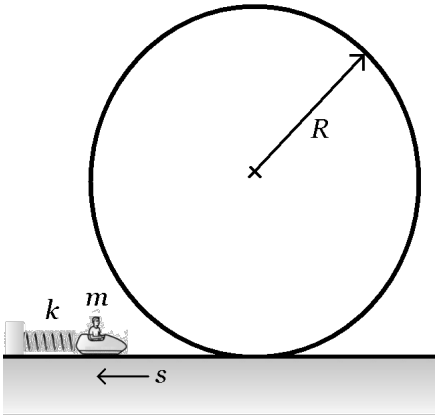
Physical Constants:

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:

I. (16 points) An amusement park sled and rider, with total mass m, is to be sent around a loop-the-loop of radius R. The sled and rider will accomplish this by compressing a large spring with Hooke's Law constant k, and being released from rest. The ground and loop frictionless. What minimum distance, s, must the spring be compressed if the loop is to be completed? Express your answer in terms of parameters defined in the problem, and physical or mathematical constants. (*On Earth.*)



II. (16 points) A huge cannon is assembled a planet that does not rotate. This planet has mass M and radius R. The cannon fires a projectile with mass m straight up at speed v_0. The projectile goes so high that the acceleration of gravity at its peak is different from that at its launch point. What maximum height above the surface does the projectile reach, in terms of parameters defined in the problem, and physical or mathematical constants?

1. (6 points) The cannon in the problem above will next be used to launch a new projectile to the same height. This new projectile has mass $m/3$. With what speed v' should this new projectile be launched?

   (a) $v' = 9v_0$
   (b) $v' = 3v_0$
   (c) $v' = v_0/9$
   (d) $v' = v_0/3$
   (e) $v' = v_0$

Initial:

III. (16 points) An object of mass m is traveling in the positive direction along the x axis with speed v. It explodes into two pieces at the instant it reaches the origin, with negligible loss of mass. Afterward, one piece, with mass $m/3$, is found to be traveling in the positive direction along the y axis with speed $v/2$. What is the **velocity** of the other piece, with mass $2m/3$, in terms parameters defined in the problem, and physical or mathematical constants?

2. (6 points) In the problem above, how is the impulse from the explosion on the piece with mass $2m/3$ related to that on the piece with mass $m/3$?

   The impulse on the piece with mass $2m/3$ is ...

   (a) equal in magnitude and in the same direction as that on the piece with mass $m/3$.
   (b) greater in magnitude and in the same direction as that on the piece with mass $m/3$.
   (c) less in magnitude and in the same direction as that on the piece with mass $m/3$.
   (d) greater in magnitude and in the opposite direction to that on the piece with mass $m/3$.
   (e) equal in magnitude and in the opposite direction to that on the piece with mass $m/3$.

3. (8 points) Two blocks, one with mass m and one with mass $2m$, are traveling along level frictionless tracks with the same momenta. Identical applied forces $\vec{F}_A$ will be used to bring each block to a stop. Compare the time and distance required to stop the blocks.

   Just as you do with "Choose one of each" questions in class, express your answer as single two-digit number, with your choices in numeric order. For example, if both the time and distance to stop the block with mass $2m$ is less than that to stop the block with mass m, your answer is "14".

   1 The time to stop the block with mass $2m$ is **less than** that to stop the block with mass m.

   2 The time to stop the block with mass $2m$ is **the same as** that to stop the block with mass m.

   3 The time to stop the block with mass $2m$ is **greater than** that to stop the block with mass m.

   4 The distance to stop the block with mass $2m$ is **less than** that to stop the block with mass m.

   5 The distance to stop the block with mass $2m$ is **the same as** that to stop the block with mass m.

   6 The distance to stop the block with mass $2m$ is **greater than** that to stop the block with mass m.

   Answer: _____

4. (8 points) Two particles collide, one of which was moving, and the other was initially at rest. Consider these results of such a collision:

   i. *Both* particles are at rest.
   ii. *One* particle is at rest.
   iii. *Neither* particle is at rest.

   Which of those results are possible?

   (a) Results *i* and *iii* only.
   (b) Results *ii* and *iii* only.
   (c) Result *ii* only.
   (d) Results *i* and *ii* only.
   (e) All results *i*, *ii*, and *iii* are possible.

Initial:

---

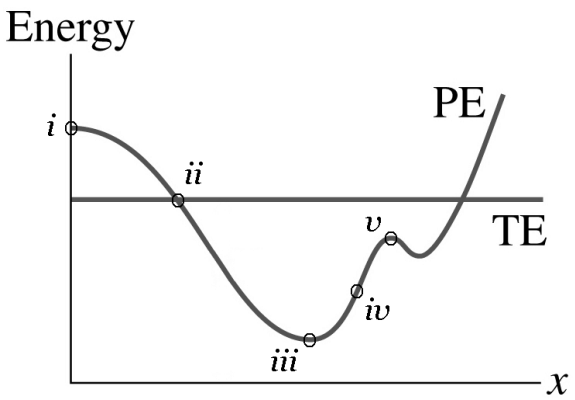
5. (8 points) Bill and Susan are each standing on identical skateboards (with ideal ball bearings), initially at rest on level ground. Bill weighs three times as much as Susan. He pushes horizontally on Susan's back, causing her to start moving away from him. Immediately after Bill stops pushing, and in the reference frame of the Earth, ...

   (a) Susan and Bill are moving away from each other, and Susan's speed is one-third that of Bill.
   (b) Susan is moving away from Bill, and Bill is stationary.
   (c) Susan and Bill are moving away from each other, and Susan's speed is three times that of Bill.
   (d) Susan and Bill are moving away from each other at equal speeds.

---

6. (8 points) The potential energy, PE, of a system depends on the location x of an object within it, according to the graph. The total mechanical energy, TE, is constant. Rank the speed of the object at each of the labeled points i through v.

   (a) $iv > ii > i = iii = v$.
   (b) $iv > ii > iii = v$. Object cannot be at i.
   (c) $iii > iv > v > ii$. Object cannot be at i.
   (d) $i > ii > v > iv > iii$.
   (e) $i > v > iv > iii$. Object cannot be at ii.



7. (8 points) The potential energy of a system depends on the location of an object within it, according to the graph. What is the force acting on an object when it is at $x = 11\,\text{m}$?

(a) $+5\,\text{N}$ (b) $-55\,\text{N}$ (c) $-1\frac{4}{11}\,\text{N}$ (d) $-5\,\text{N}$ (e) $+1\frac{4}{11}\,\text{N}$