first (given)	last (family)

Name, *printed* as it appears in Canvas

Physics 2211 A

Fall 2021

Nine-digit Tech ID

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 1–8. 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 last class meeting, Monday, December 6.

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

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

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

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

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

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

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

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

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

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

$$s = r\theta$$

$$v = r\omega$$

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Physical Constants:

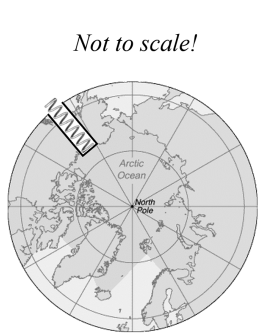
Universal Gravitation Constant $G = 6.673 \times 10^{-11}\,\mathrm{N{\cdot}m^2/kg^2}$
Gravitational Acceleration at Earth's Surface $g = 9.81\,\mathrm{m/s^2}$

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.

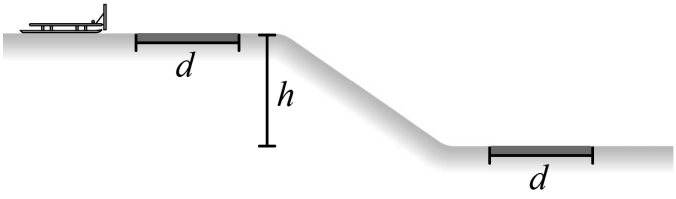
You may remove this sheet from your Quiz or Exam, but it must be submitted

Initial:

I. (16 points) A 444 kg asteroid is approaching Earth! It is detected when 19.1×10^3 km *above the Earth's surface*, traveling at 29.8 km/s. Let's protect the Earth with a giant spring that extends 1.25 km above the Earth's surface. If we're to bring the asteroid to a stop right at the surface, what spring constant will be needed? Note that Earth has mass 5.97×10^{24} kg and radius 6.38×10^3 km, and remember to neglect drag.

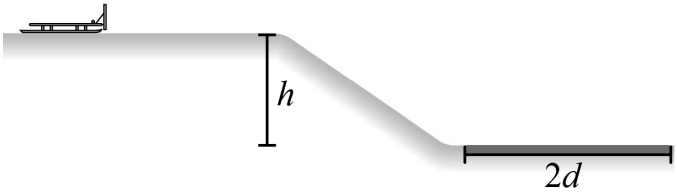


II. (16 points) A sled with mass m is sliding at speed v_0 along the frictionless level ground of Planet X. It encounters a rough patch of length d having a coefficient of kinetic friction μ_k with the sled. Then it descends frictionless hill of height h before encountering a second rough patch, identical to the first. If it emerges from this second rough patch with a speed $2v_0$, what is the gravitational acceleration g_x on Planet X? Express your answer in terms of parameters defined in the problem, and physical or mathematical constants.

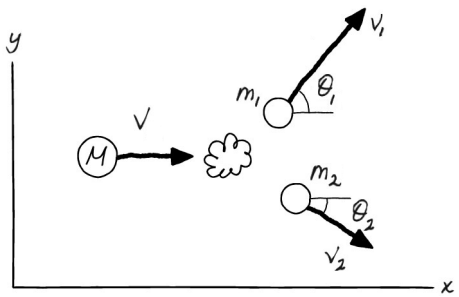


1. (6 points) What if, in the problem above, there was no rough patch before the sled reached the hill, but instead a rough patch of length $2d$ below the hill, having the same coefficient of kinetic friction μ_k? The speed of the sled emerging from the rough patch would be ...

   (a) undefined, as the sled could not emerge from a rough patch of length $2d$.
   (b) greater than $2v_0$.
   (c) between zero and $2v_0$.
   (d) zero.
   (e) $2v_0$.



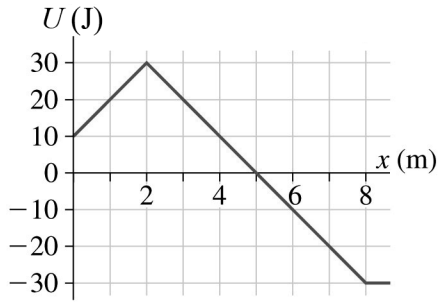
2. (6 points) An object of mass M is traveling in the $+x$ direction when it explodes into two pieces with negligible loss of mass. What is conserved in this process?



   (a) Kinetic Energy and Velocity.
   (b) Momentum.
   (c) Velocity.
   (d) Kinetic Energy.
   (e) Momentum and Kinetic Energy.

III. (16 points) In the problem above, the object of mass $M = 12\,\text{kg}$ is traveling in the $+x$ direction at $V = 9.0\,\text{m/s}$ before the explosion. Afterward, a piece with mass $m_1 = 8.0\,\text{kg}$ travels at speed $v_1 = 14\,\text{m/s}$ in a direction $\theta_1 = 52°$ from the original direction of travel, as shown. What is the **velocity** of the piece with mass $m_2 = 4.0\,\text{kg}$?

3. (6 points) A system has a potential energy, U, as a function of position x of a 2.0 kg particle within it, as shown. At one instant, the particle is observed to be traveling in the negative direction through $x = +7\,\text{m}$ at speed $2\sqrt{10}\,\text{m/s}$. If the particle has a turning point, where is it?



(a) At $x = +3\,\text{m}$
(b) At $x = +1\,\text{m}$
(c) At $x = +5\,\text{m}$
(d) The particle has no turning point.
(e) At $x = +2\,\text{m}$

4. (6 points) In the problem above, if the particle reaches position $x = +5\,\text{m}$, what is its speed there?

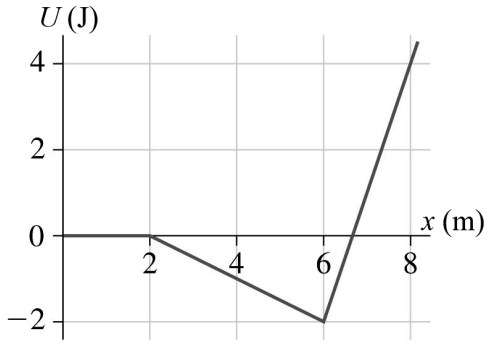
(a) $2\sqrt{10}\,\text{m/s}$
(b) The particle cannot reach $x = +5\,\text{m}$.
(c) $2\sqrt{5}\,\text{m/s}$
(d) $0\,\text{m/s}$
(e) $20\,\text{m/s}$

Initial:

---

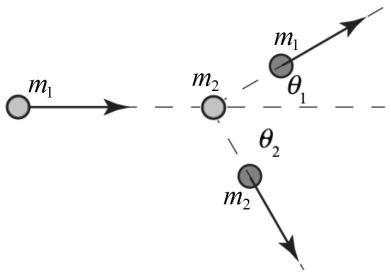
5. (7 points) A system has a potential energy, U, as a function of position x of a particle within it, as shown. Where, in the range 0 to 8 m, does the particle experience maximum force magnitude?

   (a) At 8 m
   (b) Between 0 and 2 m
   (c) Between 6 and 8 m
   (d) At 6 m
   (e) Between 2 and 6 m



---

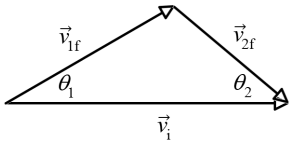
6. (7 points) An object of mass m_1 is moving with velocity $\vec{v}_{1\mathrm{i}}$ and momentum $\vec{p}_{1\mathrm{i}}$. It strikes a stationary object of mass m_2 with a glancing blow in an elastic collision. Afterward, object m_1 moves with velocity $v_{1\mathrm{f}}$ at an angle θ_1 from its original direction. Object m_2 moves with velocity $v_{2\mathrm{f}}$ at an angle θ_2 from object m_1's original direction. If m_1 is **not equal** to m_2, which sketch, if any, could represent a valid statement?



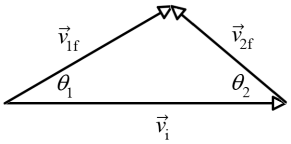
None of the others is correct

(a)

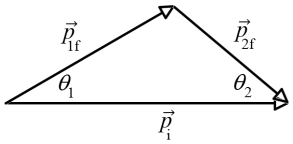
(b)



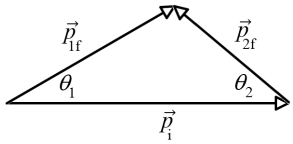
(c)



(d)

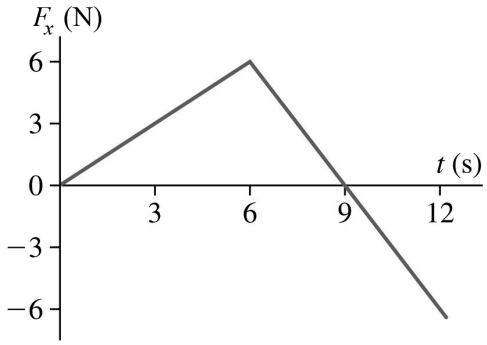


(e)



7. (7 points) A 2.0 kg object is traveling in the $+x$ direction at 3.0 m/s. At time $t = 0$, it becomes subject to the force shown. What is the object's velocity at time $t = 12$ s?

(a) +12 m/s
(b) +9.0 m/s
(c) +5.2 m/s
(d) +4.2 m/s
(e) +21 m/s



8. (7 points) A block of mass M is at rest on a level frictionless table. It is struck by a horizontally traveling bullet of mass m. The bullet **does not** embed itself in the block! Instead, it passes through to emerge from the other side. Consider a system consisting of the bullet and the block. How does the horizontal component of its momentum change in this case? (*On Earth.*)

(a) The change is negative if $m > M$, but positive if $m < M$.
(b) The change is positive if $m > M$, but negative if $m < M$.
(c) The change is zero.
(d) The change is positive.
(e) The change is negative.