first (given)	last (family)

Name, *printed* as it appears in Canvas

Physics 2211 A

Fall 2020

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 when the next quiz is administered.

Select your Multiple Choice answers directly in Gradescope.

Quiz and Exam Formulæ & Constants

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

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

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

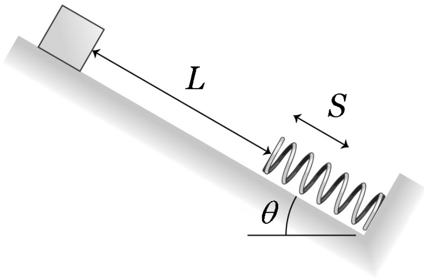
$$\vec{r}_{\text{cm}} = \frac{\sum \vec{r}_i m_i}{\sum m_i}$$
$$\vec{r}_{\text{cm}} = \frac{\int \vec{r}\,dm}{\int dm}$$
$$I = \sum m_i r_i^2$$
$$I = \int r^2\,dm$$
$$I = I_{\text{cm}} + Md^2$$
$$\vec{L} = \vec{r} \times \vec{p}$$
$$\vec{L} = I\vec{\omega}$$
$$x = A\cos(\omega t + \phi_0)$$
$$\vec{a}_{\text{x}}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

Physical Constants:

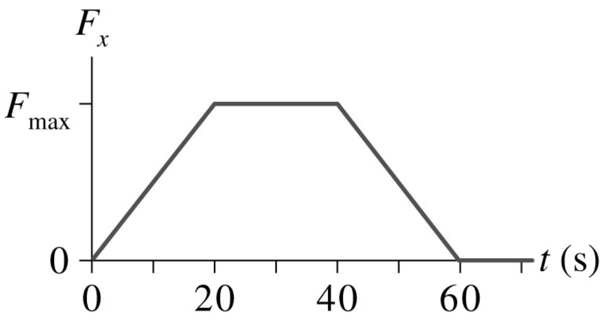
Universal Gravitation Constant $G = 6.673 \times 10^{-11}\,\text{N}\cdot\text{m}^2/\text{kg}^2$
Gravitational Acceleration at Earth's Surface $g = 9.81\,\text{m/s}^2$

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.

I. (16 points) A block of mass m slides down a plane that makes an angle θ with the horizontal. The block was initially at rest, and there is friction between the block and the plane. It slides a distance L where it contacts a spring with spring constant k. It continues sliding, compressing the spring to a distance S where it momentarily comes to rest. What is the coefficient of kinetic friction between the block and the plane? Express your answer in terms of parameters defined in the problem and physical or mathematical constants. (*On Earth.*)



1. (6 points) Far out in space, where gravity is negligible, a 550 kg rocket traveling at 120 m/s in the $+x$ direction fires its engines. The figure shows the thrust force as a function of time, with a maximum thrust magnitude of $F_{\text{max}} = 960\,\text{N}$. At what time does the rocket reach its maximum speed?

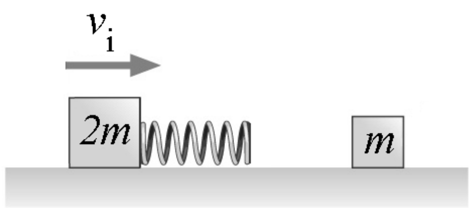


(a) $t = 60\,\text{s}$
(b) $t = 20\,\text{s}$
(c) $t = 40\,\text{s}$
(d) $t = 0\,\text{s}$
(e) $t = 30\,\text{s}$

II. (16 points) In the problem above, what is the maximum speed of the rocket during these 60 s? (The mass lost by the rocket is negligible.)

2. (6 points) A block of mass $2m$ has a massless spring with spring constant k attached to its front, parallel to the ground. This block slides across a frictionless horizontal surface at speed $v_{\rm i}$ toward a stationary block of mass m. How does the speed of the block with mass $2m$ on the left, $v_{\rm L}$, compare to that of the block with mass m on the right, $v_{\rm R}$, at the instant of maximum compression?

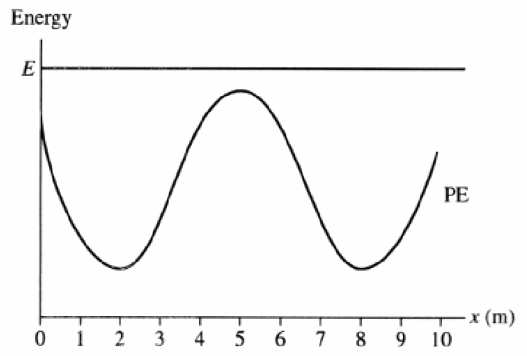
   (a) $2v_{\rm R} > v_{\rm L} > v_{\rm R}$
   (b) $v_{\rm L} = v_{\rm R}$
   (c) $v_{\rm L} = \frac{1}{2}v_{\rm R}$
   (d) $v_{\rm R} > v_{\rm L} > \frac{1}{2}v_{\rm R}$
   (e) $v_{\rm L} = 2v_{\rm R}$



III. (16 points) In the problem above, what is the maximum compression of the spring during the collision? Express your result in terms of any or all of m, k, $v_{\rm i}$, and physical or mathematical constants. (*On Earth.*)

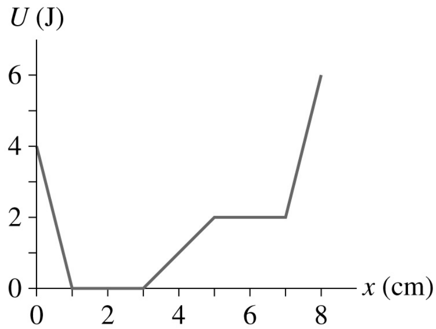
3. (8 points) A system with total energy E has a potential energy PE that depends on the position, x, of a particle within it. At a particular instant, the particle is at $x = 0\,\text{m}$ and moving to the right. What are the particle's turning points in the range shown by the graph?

(a) At approximately 0 m, 3.5 m, 6.5 m, and 10 m.
(b) At approximately 2 m and 8 m.
(c) At approximately 0 m and 10 m.
(d) At approximately 3.5 m and 6.5 m.
(e) It has no turning points in the range $0 \le x \le 10\,\text{m}$.



4. (8 points) A particle in a system moves along the x axis under the influence of a conservative force within the system. The graph shows the potential energy of the system as a function of the position of the particle. At what values of x does the force have the greatest positive value?

(a) Between $x = 0\,\text{cm}$ and $x = 1\,\text{cm}$
(b) Between $x = 7\,\text{cm}$ and $x = 8\,\text{cm}$
(c) Between $x = 5\,\text{cm}$ and $x = 7\,\text{cm}$
(d) Between $x = 1\,\text{cm}$ and $x = 3\,\text{cm}$
(e) Between $x = 3\,\text{cm}$ and $x = 5\,\text{cm}$

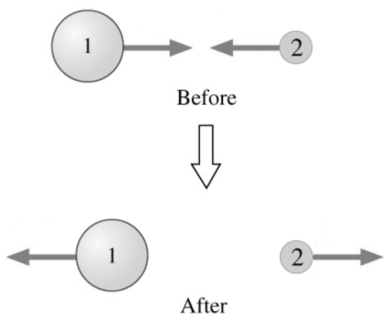


5. (8 points) Taking the zero point of gravitational potential energy to be at infinite separation, under what conditions will a space probe eventually escape the Earth's gravity?

   It will escape the Earth's gravity if ...

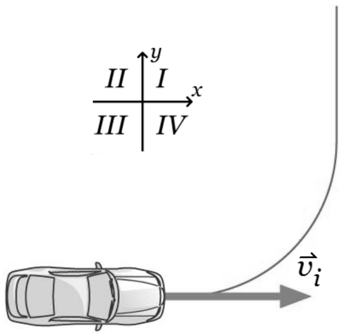
   (a) the gravitational potential energy of the Earth/probe system is greater than or equal to zero.
   (b) the probe's kinetic energy is greater than or equal to zero.
   (c) the probe's kinetic energy is greater than or equal to the gravitational potential energy of the Earth/probe system.
   (d) the mechanical energy of the Earth/probe system is half its gravitational potential energy.
   (e) the mechanical energy of the Earth/probe system is greater than or equal to zero.

6. (8 points) Object 1, with mass m_1, is travelling to the right with 70 J of kinetic energy. Object 2, with mass m_2, is travelling to the left with 30 J of kinetic energy. They undergo a perfectly elastic collision, after which object 1 is travelling to the left with 16 J of kinetic energy and object 2 is travelling to the right. If $m_1 > m_2$, what is the kinetic energy of object 2 after the collision?



   (a) -56 J
   (b) +29 J
   (c) -29 J
   (d) +84 J
   (e) +56 J

7. (8 points) The automobile in the top-down illustration is traveling in the $+x$ direction with velocity $\vec{v}_i$. It then turns to travel in the $+y$ direction *at constant speed*. What direction, if any, is the impulse on the car for this process?



(a) Somewhere in quadrant II.
(b) In the $+y$ direction.
(c) In no direction, as the impulse is zero.
(d) In the $-x$ direction.
(e) Somewhere in quadrant IV.