first (given)	last (family)

Name, *printed* as it appears in Canvas

Physics 2211 A

Fall 2020

Nine-digit Tech ID

Quiz

3A

- 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

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

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

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

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

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

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

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

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

$$s = r\theta$$

$$v = r\omega$$

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

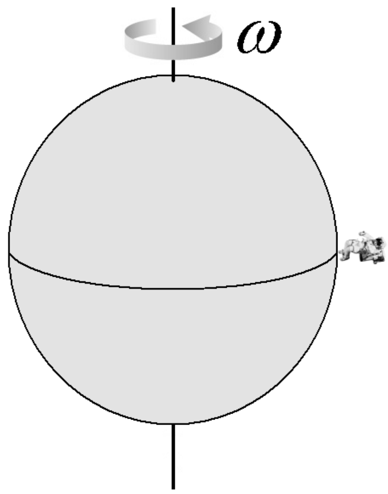
Physical Constants:

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.

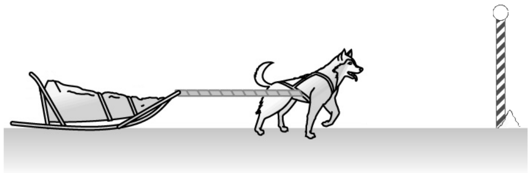
I. (16 points) Astronaut Arlene stands at the equator of the (fictional) planet Planteen and measures her apparent weight to be 220 N. Arlene knows her own mass to be 82 kg, while Planteen has a mass of 3.0×10^{23} kg and a radius of 2.5×10^{6} m. With what angular speed does Planteen rotate on its axis?



1. (6 points) It is the end of the dog sled race, and a dog approaches the finish line over level snow pulling a 55 kg sled. At 5.0 m from the finish line, the sled is travelling at 6.0 m/s. The coefficient of kinetic friction between the sled and the snow is 0.18 in these last 5.0 m. The tiring dog exerts a force, $\vec{F}$, on the sled whose magnitude decreases as the finish line is approached, according to

$$\left|\vec{F}(x)\right| = C\sqrt{x}$$

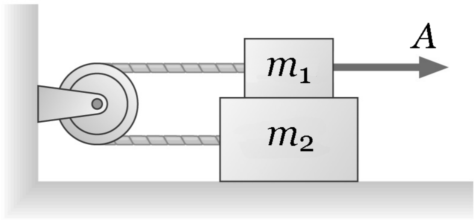
where C is a constant equal to $32\,\mathrm{N/m^{1/2}}$ and x is the distance from the sled to the finish line. Describe the speed of the sled as it approaches the finish line. *(On Earth.)*



(a) The speed of the sled remains constant.
(b) The speed of the sled always increases.
(c) The speed of the sled decreases at first, then increases.
(d) The speed of the sled always decreases.
(e) The speed of the sled increases at first, then decreases.

II. (16 points) In the problem above, what is the speed of the sled as it crosses the finish line?

2. The upper block in the illustration, with mass m_1, is pulled horizontally by a rope with a tension of magnitude A. The lower block has mass m_2, and rests on a horizontal frictionless surface. The coefficient of kinetic friction between the two blocks is μ_k. How does the frictional force on the bottom block, $\vec{f}_2$, compare to that on the top block, $\vec{f}_1$? *(On Earth.)*

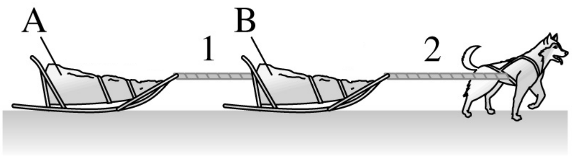


(a) $\vec{f}_2$ is in the opposite direction of $\vec{f}_1$, and $f_2 > f_1$.
(b) $\vec{f}_2$ is in the same direction as $\vec{f}_1$, and $f_2 = f_1$.
(c) $\vec{f}_2$ is in the same direction as $\vec{f}_1$, and $f_2 > f_1$.
(d) $\vec{f}_2$ is in the opposite direction of $\vec{f}_1$, and $f_2 = f_1$.
(e) $\vec{f}_2$ is in the opposite direction of $\vec{f}_1$, and $f_2 < f_1$.

III. In the problem above, what is the acceleration magnitude of the lower block, in terms of any or all of m_1, m_2, A, μ_k, and physical or mathematical constants?

3. (8 points) It is the beginning of the dog sled race, and the illustrated dog accelerates toward the right as it leaves the starting line over level snow, pulling two sleds of equal mass. The runners of one sled have been waxed to reduce the coefficient of kinetic friction between that sled and the snow. How is the tension in rope 2 related to the tension in rope 1? (*On Earth.*)

(a) Tension in rope 2 is greater than tension in rope 1 if the front sled, B, has waxed runners.
(b) Tension in rope 2 is greater than tension in rope 1 if the rear sled, A, has waxed runners.
(c) Tension in rope 2 is the same as tension in rope 1, regardless of which sled has waxed runners.
(d) Tension in rope 2 is less than tension in rope 1, regardless of which sled has waxed runners.
(e) Tension in rope 2 is greater than tension in rope 1, regardless of which sled has waxed runners.



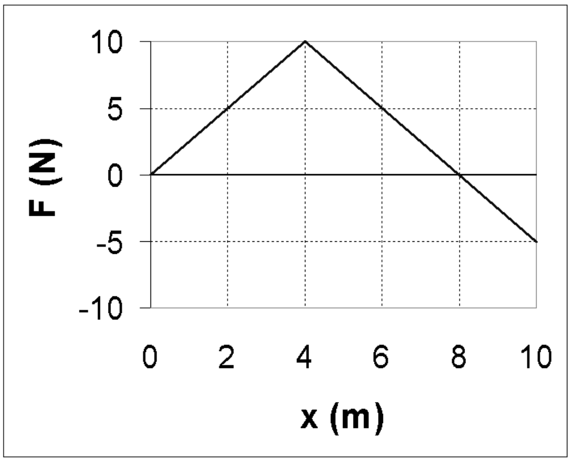
4. (8 points) A merry-go-round is spinning at a constant angular velocity. A man walks from the center of the merry-go-round out to the edge along a radius. If the man does not slip, what must be true? (*On Earth.*)

As the man approaches the edge ...

(a) the maximum force of static friction must decrease.
(b) the maximum force of static friction must increase.
(c) the force of static friction must increase.
(d) there is no change in the force of friction.
(e) the force of static friction must decrease.

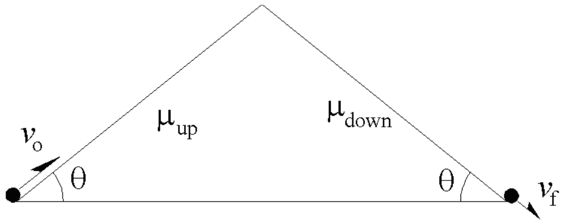
5. (8 points) A 2.0 kg particle moving on the x axis is subject to the force shown on the graph. If the particle's velocity is +5.0 m/s as it passes through the origin, what is its kinetic energy when it reaches +10 m?

(a) 70 J
(b) 35 J
(c) 60 J
(d) 25 J
(e) 50 J



6. (8 points) A block of mass m is given an initial push so that it slides up the left side of a ramp with kinetic friction coefficient μ_{up}. When it reaches the top it slides smoothly over the peak and then down the right side. The kinetic friction coefficient on the right side is μ_{down}. Compare the time for the block to slide up the left side with that for it to slide down the right side. (Hint: consider the block's kinetic energy.) (*On Earth.*)

(a) The block takes more time to slide down the right side than up the left side.
(b) The block takes less time to slide down the right side than up the left side.
(c) Which side takes more time depends on the relationship between μ_{up} and μ_{down}.
(d) The block takes the same time to slide down the right side as up the left side.



7. (8 points) Four students with the indicated masses run up their staircases in the indicated times. Rank, from greatest to least, their power outputs.

(a) $iv > i = iii > ii$
(b) $iv > i = ii > iii$
(c) $ii > iv > i > iii$
(d) $ii > iv > i = iii$
(e) $ii > i = iii > iv$