Quiz and Exam Formulæ & Constants

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

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

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

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

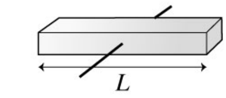
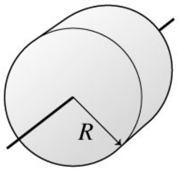
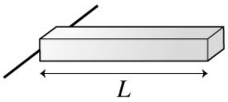
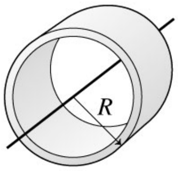
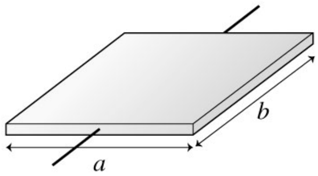
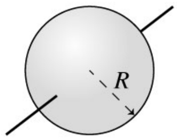
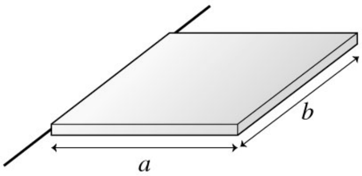
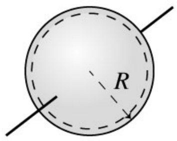
Physical Constants:

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.

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

TABLE 12.2 Moments of inertia of objects with uniform density

Object and axis	Picture	I	Object and axis	Picture	I
Thin rod, about center		$\frac{1}{12}ML^2$	Cylinder or disk, about center		$\frac{1}{2}MR^2$
Thin rod, about end		$\frac{1}{3}ML^2$	Cylindrical hoop, about center		MR^2
Plane or slab, about center		$\frac{1}{12}Ma^2$	Solid sphere, about diameter		$\frac{2}{5}MR^2$
Plane or slab, about edge		$\frac{1}{3}Ma^2$	Spherical shell, about diameter		$\frac{2}{3}MR^2$

first (given)	last (family)

Name, *printed* as it appears in Canvas

Physics 2211 AB

Spring 2020

Nine-digit Tech ID

Exam

5A

- **Print** your name and nine-digit Tech ID *very neatly* in the spaces above.
- [redacted]
- [redacted]
- [redacted]
- [redacted]
- [redacted]
- [redacted]

[redacted]

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

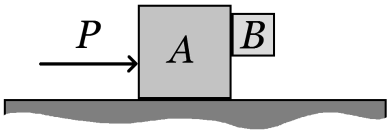
	a	b	c	d	e		a	b	c	d	e
1	ⓐ	ⓑ	ⓒ	ⓓ	ⓔ	7	ⓐ	ⓑ	ⓒ	ⓓ	ⓔ
2	ⓐ	ⓑ	ⓒ	ⓓ	ⓔ	8	ⓐ	ⓑ	ⓒ	ⓓ	ⓔ
3	ⓐ	ⓑ	ⓒ	ⓓ	ⓔ	9	ⓐ	ⓑ	ⓒ	ⓓ	ⓔ
4	ⓐ	ⓑ	ⓒ	ⓓ	ⓔ	10	ⓐ	ⓑ	ⓒ	ⓓ	ⓔ
5	ⓐ	ⓑ	ⓒ	ⓓ	ⓔ	11	ⓐ	ⓑ	ⓒ	ⓓ	ⓔ
6	ⓐ	ⓑ	ⓒ	ⓓ	ⓔ	12	ⓐ	ⓑ	ⓒ	ⓓ	ⓔ
	a	b	c	d	e		a	b	c	d	e

1. (16 points) An object moves in one dimension with a position that varies with time according to

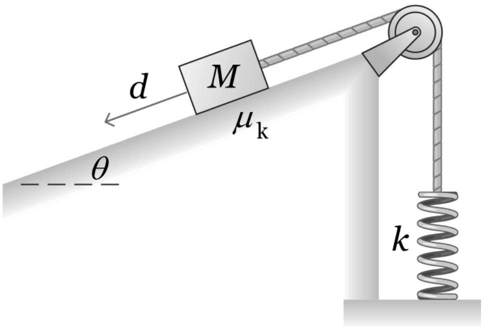
$$x = At^4 + Bt^2 + C$$

where $A = 2\,\mathrm{m/s^4}$, $B = 3\,\mathrm{m/s^2}$, and $C = 4\,\mathrm{m}$. What is the average acceleration of the object from $t = -1\,\mathrm{s}$ to $t = +2\,\mathrm{s}$?

2. (16 points) Block A in the illustration, with mass $m_A = 5.6\,\text{kg}$, slides along a horizontal frictionless plane. Block B, with mass $m_B = 1.2\,\text{kg}$ has a coefficient of static friction $\mu_s = 0.75$ and a coefficient of kinetic friction $\mu_k = 0.45$ with the front face of block A. What is the minimum magnitude of a horizontal push force, P, on block A so that block B does not slide downward? (*On Earth.*)



3. (16 points) A block of mass $M = 15\,\text{kg}$ is held at rest on a frictionless slope that makes an angle $\theta = 12°$ with the horizontal. The block is attached to a vertical spring by an ideal cord that passes over an ideal pulley on a frictionless axle. The spring has Hooke's Law (spring) constant $k = 28\,\text{N/m}$ and is at its natural length (neither stretched nor compressed). Find the speed of the block when it has travelled a distance $d = 72\,\text{cm}$ down along the slope after release. (*On Earth.*)



4. ($4\frac{1}{3}$ points) If

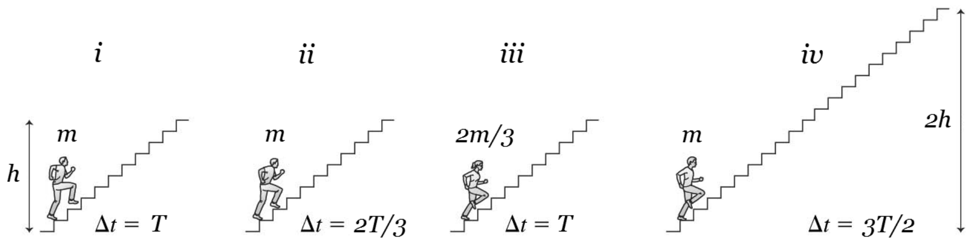
$$\vec{A} = (6\hat{\imath} - 1\hat{\jmath})\,\text{m/s} \qquad \text{and} \qquad \vec{B} = (5\hat{\imath} - 2\hat{\jmath})\,\text{m/s}$$

what is the magnitude of $\vec{A} - 2\vec{B}$?

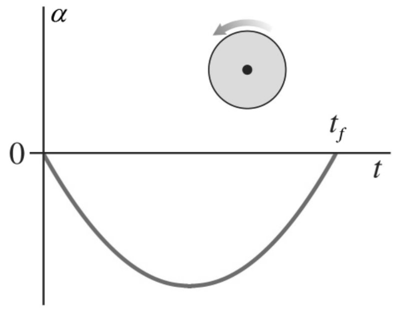
(a) 5 m/s (b) 7 m/s (c) -1 m/s (d) 1 m/s (e) -7 m/s

5. ($4\frac{1}{3}$ points) Four students with the indicated masses run up their staircases in the indicated times. Rank, from greatest to least, their power outputs.

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



6. ($4\frac{1}{3}$ points) A wheel is rotating counterclockwise with initial angular velocity ω_0. Let this direction be positive. It is then given a non-uniform angular acceleration, α, shown in the graph, from time $t = 0$ to time $t = t_f$. How does the *magnitude* of the angular velocity, ω_f, at time t_f, compare to the *magnitude* of ω_0?



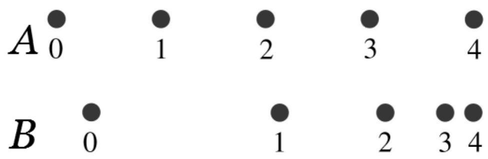
(a) $|\omega_f|$ is less than $|\omega_0|$, but $|\omega_f|$ is not zero.
(b) $|\omega_f|$ is greater than $|\omega_0|$.
(c) This cannot be determined from the information provided.
(d) $|\omega_f|$ is less than $|\omega_0|$, because $|\omega_f|$ is zero.
(e) $|\omega_f|$ is the same as $|\omega_0|$.

7. ($4\frac{1}{3}$ 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 *times* required to stop the blocks.

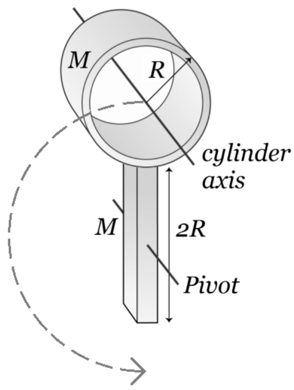
(a) The time to stop the block with mass $2m$ is **the same as** that to stop the block with mass m.
(b) The time to stop the block with mass $2m$ is **less than** that to stop the block with mass m.
(c) The relative times to stop the blocks **cannot be determined** from the information provided.
(d) The time to stop the block with mass $2m$ is **greater than** that to stop the block with mass m.

8. ($4\frac{1}{3}$ points) The motion diagrams for two objects, A and B are illustrated. Describe the acceleration of each object.

(a) Object A has an acceleration of zero, while object B has an acceleration to the left.
(b) Both objects A and B have an acceleration of zero.
(c) Object A has an acceleration to the right, while object B has an acceleration to the left.
(d) Object A has an acceleration of zero, while object B has an acceleration to the right
(e) Object A has an acceleration to the left, while object B has an acceleration to the right.



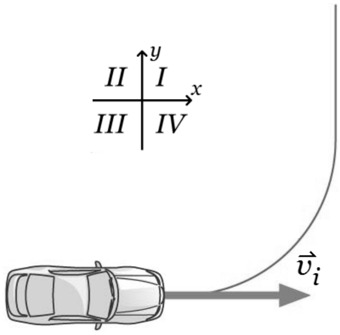
9. ($4\frac{1}{3}$ points) A cylindrical hoop of mass M and radius R is attached to the end of a thin rod. The rod also has mass M, and has length $2R$. A frictionless horizontal axle passes through the center of the rod, and the resulting object is positioned vertically in unstable equilibrium, as illustrated. A gentle nudge causes the object to begin rotating. How does the net torque magnitude on the object about the pivot change as it rotates from the illustrated position of unstable equilibrium to the position of stable equilibrium? (*On Earth.*)



(a) The torque magnitude remains constant.
(b) The torque magnitude first increases, then decreases.
(c) The torque magnitude first decreases, then increases.
(d) The torque magnitude only decreases.
(e) The torque magnitude only increases.

10. ($4\frac{1}{3}$ 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) Somewhere in quadrant IV.
(d) In the $-x$ direction.
(e) In no direction, as the impulse is zero.

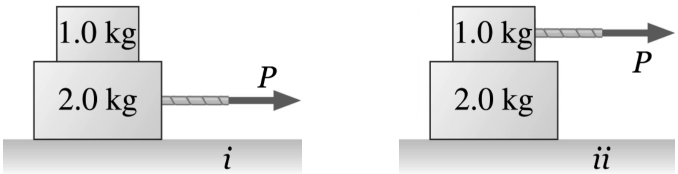


11. ($4\frac{1}{3}$ points) A satellite with mass m travels around the Earth with angular speed ω_E in a circular orbit with radius R. A satellite with mass $10m$ travels around Mars with angular speed ω_M in a circular orbit with the same radius R. The mass of Mars is one-tenth the mass of the Earth. Compare the angular speeds of the two satellites.

(a) $\omega_M = \omega_E$
(b) $\omega_M = \omega_E/10$
(c) $\omega_M = \omega_E/\sqrt{10}$
(d) $\omega_M = 10\omega_E$
(e) $\omega_M = \sqrt{10}\omega_E$

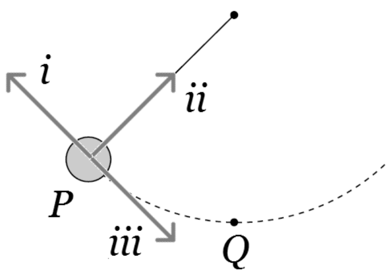
12. ($4\frac{1}{3}$ points) A block with a mass of 2.0 kg lies on a frictionless horizontal surface. A block with a mass of 1.0 kg is placed on top of it. A rope will be attached to either the bottom block (situation i) or the top block (situation ii) and pulled with a horizontal force magnitude P. The coefficient of static friction between the blocks is sufficient that the blocks do not slide relative to each other in either situation. Compare the force of static friction between the blocks f_i in situation i, with the force of static friction between the blocks f_{ii} in situation ii.

(a) $f_{ii} = f_i$
(b) $f_{ii} = f_i/2$
(c) $f_i < f_{ii} < 2f_i$
(d) $f_i/2 < f_{ii} < f_i$
(e) $f_{ii} = 2f_i$

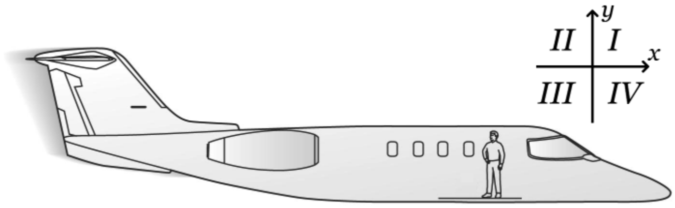


13. ($4\frac{1}{3}$ points) The pendulum in the illustration is swinging back and forth. What is the direction of its acceleration at the highest point of its swing (position P)? (*On Earth.*)

(a) Between directions i and ii.
(b) Direction iii.
(c) Direction i.
(d) Between directions ii and iii.
(e) Direction ii.

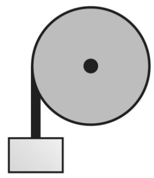


14. ($4\frac{1}{3}$ points) Carlos is a skydiver. He jumps out of the illustrated airplane, which is traveling horizontally at a speed greater than Carlos' terminal speed. Immediately after jumping out of the airplane, and before reaching his terminal speed, what is the direction of Carlos' acceleration? (*On Earth.* Do NOT neglect drag!)



(a) Somewhere in quadrant IV.
(b) Somewhere in quadrant II.
(c) In the $-y$ direction.
(d) In the $-x$ direction.
(e) Somewhere in quadrant III.

15. ($4\frac{1}{3}$ points) An object with circular cross-section has mass M and radius R. An ideal cord is wrapped around it and tied to a block of mass m, as illustrated. If it matters, which of these four uniform objects with circular cross-section from the Table of Moments of Inertia should be selected to *maximize* the acceleration magnitude of the block upon release?



(a) It does not matter which of the four uniform objects with circular cross-section from the Table is selected.
(b) The object should be a solid sphere.
(c) The object should be a spherical shell.
(d) The object should be a solid cylinder or disk.
(e) The object should be a cylindrical hoop.