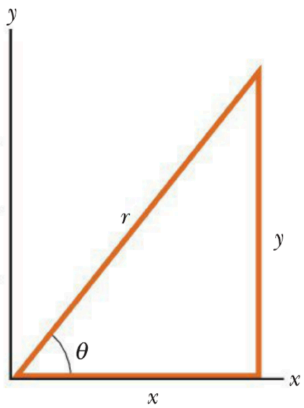
MIDTERM 3 SOLUTIONS, Spring 2019

Print your name clearly. There are 20 questions on this test, worth 5 points each. There is only one correct answer for each question. Clearly circle your answer.

POTENTIALLY USEFUL INFORMATION (**SOME EQUATIONS ARE ONLY VALID IN SPECIFIC SITUATIONS**):

Conversions: 1 m=3.281 ft 1 mile=1609 m 1 kg=2.2 pounds g=9.8 m/s^2 ρ_{water}=1000 kg/m^3

1 pound=4.45 N 1 hp=746 W G=6.67 x 10^{-11} N m^2/kg^2 1 atm=1.013 x 10^5 N/m^2



$\sin\theta = \frac{y}{r}$

$\cos\theta = \frac{x}{r}$

$\tan\theta = \frac{y}{x}$

$r^2 = x^2 + y^2$

1D or 2D motion:

$$\bar{v} = \frac{\Delta x}{\Delta t} \qquad \bar{a} = \frac{\Delta v}{\Delta t} \qquad v = \lim_{\Delta t \to 0} \frac{\Delta x}{\Delta t} \qquad a = \lim_{\Delta t \to 0} \frac{\Delta v}{\Delta t}$$

$$x = x_o + \bar{v}t = x_o + v_o t + \frac{1}{2}at^2 \qquad v = v_o + at$$

$$v^2 = v_o^2 + 2a(x - x_o)$$

Quadratic formula:

$$ax^2 + bx + c = 0 \rightarrow x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

$$\vec{F} = \sum_i \vec{F}_i = m\vec{a} = \frac{\Delta \vec{p}}{\Delta t} \quad F_g = mg \quad F_{sp} = -kx \quad F_s \le \mu_s n \quad F_k = \mu_k n \quad \vec{F}_{AB} = -\vec{F}_{BA}$$

$$W = F_x \Delta x = \Delta KE + \Delta PE \quad KE = \tfrac{1}{2}mv^2 = \frac{p^2}{2m} \quad PE_g = mgy \quad PE_{sp} = \tfrac{1}{2}kx^2 \quad \bar{P} = \frac{W}{\Delta t} = F\bar{v}$$

$$\vec{p} = m\vec{v} \quad \vec{I} = \vec{F}\Delta t = \Delta\vec{p} = m\Delta\vec{v} \quad m_1\vec{v}_{1i} + m_2\vec{v}_{2i} = m_1\vec{v}_{1f} + m_2\vec{v}_{2f} \quad KE_i + PE_i = KE_f + PE_f$$

$$v_f = \frac{m_1 v_{1i} + m_2 v_{2i}}{m_1 + m_2} \quad v_{1i} - v_{2i} = -(v_{1f} - v_{2f})$$

$$\omega = \omega_i + \alpha t$$

$$\Delta\theta = \omega_i t + \tfrac{1}{2}\alpha t^2$$

$$v_f - v_i = v_e ln\left(\frac{M_i}{M_f}\right) \quad \omega^2 = \omega_i^2 + 2\alpha\Delta\theta \quad a_c = \frac{v^2}{r} = r\omega^2 \quad F = G\frac{m_1 m_2}{r^2}$$

$$\Delta x = r\Delta\theta \quad v = r\omega \quad a_{tan} = r\alpha \quad F_c = ma_c = m\frac{v^2}{r} = mr\omega^2$$

$x_{cg} = \frac{\sum m_i x_i}{\sum m_i}$ $I = \sum mr^2$ $I_{disk} = \frac{1}{2}mR^2$ $I_{sphere} = \frac{2}{5}mR^2$ $L = I\omega$

$L_f = I_f\omega_f = L_i = I_i\omega_i$ $\tau = rF\sin(\theta)$ $\tau = I\alpha$

$\sum \tau = \frac{L_f - L_i}{\Delta t} = \frac{\Delta L}{\Delta t}$ $\rho \equiv \frac{m}{V}$ $P = \frac{F}{A}$ $\frac{F}{A} = Y\frac{\Delta L}{L_0}$

$\frac{F}{A} = S\frac{\Delta x}{h}$ $\Delta P = -B\frac{\Delta V}{V}$ $P = P_0 + \rho gh$ $\frac{F_1}{A_1} = \frac{F_2}{A_2}$

$A_1V_1 = A_2V_2$ $P_1 + \frac{1}{2}\rho v_1^2 + \rho g y_1 = const.$ $B = \rho_{fluid} \cdot V_{fluid} \cdot g$

Area of a circle = πr^2 Volume of a circle = $4\pi r^3/3$

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1. If we take a rocket with a circular nozzle (the part where the exhaust comes out) and shrink the radius of the nozzle to ½ its original size, but keep the mass of the rocket and of the propellant the same, and launch it from rest, by what factor will we increase the final velocity at burnout? You may treat the exhaust like a fluid for the purpose of this problem.

a.) 2 b.) ln 2 c.) 1.6 d.) e^2 **e.) 4**

2. If we double the mass of propellant in a rocket, from initially being equal to the mass of the empty rocket, to instead being twice the mass of the empty rocket, by what factor do we increase the change in velocity at burnout?

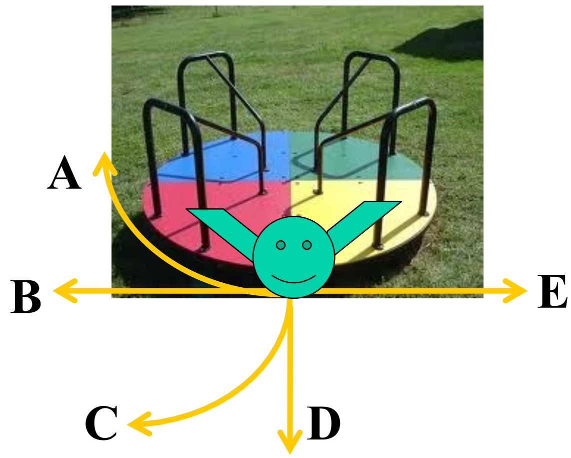
a.) 2 b.) ln 2 **c.) 1.6** d.) e^2 e.) 4

3. The tires on a car have a diameter of 2.0 ft and are warranted for 60,000 miles. How many revolutions will one of these tires rotate through during the warranty period.

a.) 2.5×10^7 b.) 4700 c.) 30000 **d.) 5.0×10^7** e.) 1.6×10^8

4. Big Ben in London and a little alarm clock in Morgantown both keep perfect time. Which minute hand has the larger angular velocity?

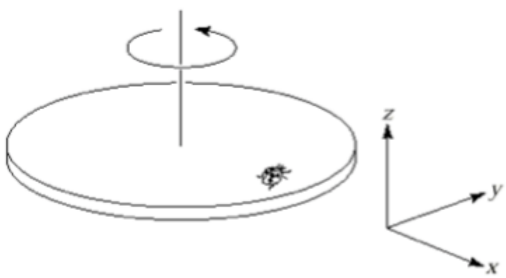
a.) need more information b.) Big Ben c.) little alarm clock. **d.) both are the same**



5. The merry go round pictured above is turning clockwise. If you are standing on the bottom edge (boundary between red and yellow), what direction would you go if you let go? Choose the letter option corresponding to the correct path.

a.) A **b.) B** c.) C d.) D e.) E

Questions 6-9 pertain to the figure below, where a ladybug is located at the edge of a spinning disk.



6. In which Cartesian direction does the centripetal acceleration point?

a.) +*x* direction **b.) -*x* direction** c.) +*y* direction d.) -*y* direction e.) +*z* direction

7. In which Cartesian direction does the tangential acceleration point?

a.) +*x* direction b.) -*x* direction **c.) +*y* direction** d.) -*y* direction e.) +*z* direction

8. Assuming a motor is maintaining the disk's rotation, in which Cartesian direction does the torque from the motor point?

a.) +*x* direction b.) -*x* direction c.) +*y* direction d.) -*y* direction **e.) +*z* direction**

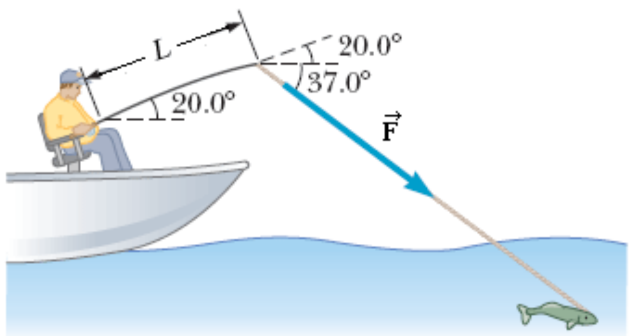
9. If the picture shows the starting position of the ladybug, and the disk starts rotating from rest with a constant acceleration of 0.5 rad/s^2, what will the ladybug's angular velocity be after 1 second?

a.) 0.25 *rad* b.) 0.25 *rad/s* c.) 0.5 *rad* **d.) 0.5 *rad/s*** e.) 0.5 rad/s^2

10. What is the tangential velocity of the Moon as it circles the Earth, relative to the Earth? The mass of the Earth is 6×10^{24} kg, the mass of the Moon is 7×10^{22} kg, and the distance between them is 4×10^8 m.

a.) 0.1 km/s **b.) 1 km/s** c.) 10 km/s d.) 100 km/s. e.) 1000 km/s

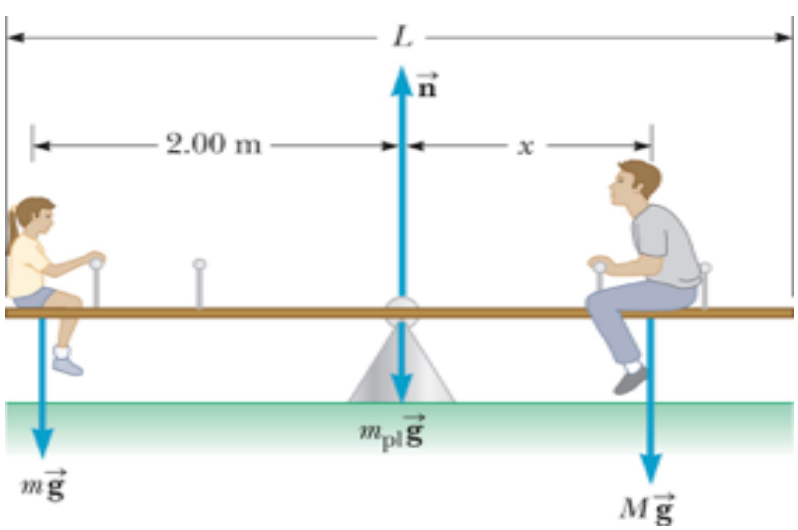
Question 11 pertains to the figure below.



11. If the fisherman pictured above holds his fishing rod at an angle of 20.0° with the horizontal, and the rod is 1.50 m long, what is the magnitude of the torque exerted by the fish about an axis perpendicular to the rod and passing through the fisherman's hand, if the fish pulls on the fishing line with a force F = 100 N at an angle 37.0° below the horizontal?

a.) 126 N m b.) 98 N m c.) 183 N m d.) 356 N m e.) 1296 N m

Questions 12-13 pertain to the figure below, where a woman of mass m = 55 kg sits on the left end of a see-saw that has length L = 4 m, pivoted in the middle.



12. If the man has mass M = 75 kg and the plank has mass m_{pl} = 12 kg, find the value for *x*, the distance between the man and the pivot point, such that the man and woman will balance.

a.) 1.0 m b.) 1.25 m **c.) 1.5 m** d.) 1.75 m e.) 2.0 m

13. Assuming again that the man has mass M = 75 kg and the plank has mass m_{pl} = 12 kg, find the value for the normal force exerted by the pivot on the plank.

a.) 120 N b.) 142 kg c.) 142 N d.) 1300 N **e.) 1400 N**

Questions 14-16 pertain to the figure below.

14. If a hoop, a disk, and a sphere, all of the same total mass, slide without rolling down an incline, which will reach the bottom first?

a.) hoop b.) disk c.) sphere **d.) all will be the same** e.) need more information

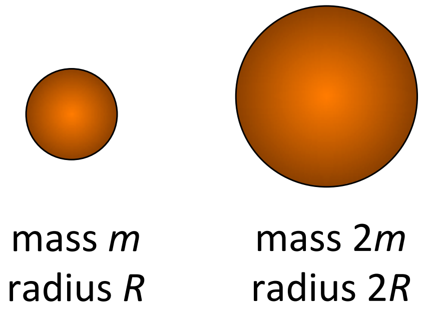
15. If a hoop, a disk, and a sphere, all of the same total mass, roll down an incline, which will reach the bottom first?

a.) hoop b.) disk **c.) sphere** d.) all will be the same e.) need more information

16. If a hoop, a disk, and a sphere, all of the same total mass, roll down an incline, what is the ratio of the sphere's **total** kinetic energy to the hoop's **total** kinetic energy?

a.) 1 b.) 1/2 c.) 3/4 d.) 5/8 **e.) 7/10**

Question 17 pertains to the figure below.



17. In the picture above, compared to the sphere on the left, the larger sphere on the right has

a.) twice the density b.) the same density c.) 1/2 the density **d.) 1/4 the density** e.) 1/8 the density

18. Two blocks (A and B) have the same size and shape. Block A floats in the water, but Block B sinks in the water. Which block has the larger buoyant force on it?

a.) Block A **b.) Block B** c.) they are the same d.) need more information

19. A fluid flows through a pipe of varying radius. If it flows in from the left with a velocity v, and the radius is twice as large on the right end than on the left end, the fluid will flow out on the right with a velocity of

a.) *v*/4 b.) *v*/2 c.) *v* d.) 2*v* e.) 4*v*

20. If you consider a 40 meter tall cylindrical column of water with a 1 meter radius, where the top of the column is exposed to the atmosphere, the pressure required to support the bottom of the column is

a.) $10^5\ N/m^2$ b.) $10^6\ N/m^2$ **c.) $\mathbf{5 \times 10^5\ N/m^2}$** d.) $5 \times 10^6\ N/m^2$ e.) $5 \times 10^7\ N/m^2$