*(4 pts each)* In problems 1 – 5 find the appropriate limit. Give EXACT answers!

1. $\lim_{x\to 4^+} \dfrac{4-x}{|4-x|}$

2. $\lim_{x\to\infty} \left(\sqrt{x^2+5x+2}-x\right)$

3. $\lim_{x\to 0} \dfrac{x}{\arctan(4x)}$

4. $\lim_{x\to\infty} \left(\dfrac{3x+1}{3x+2}\right)^{2x+1}$

5. $\lim_{x\to 1} (2-x)^{\tan(\pi x/2)}$

*(3 pts each)* In problems 6-7 find the derivative with respect to $x$ of the given function In each problem begin by writing for example, $f'(x) =$ ***DO NOT SIMPLIFY***

6. $f(x) = (\sin(3x+7))^{\ln(x)}$

(find **y'**) 7. $x^2 + 4xy - \sin(y) = 12$

*(5 pts each)* In problems 8-13, evaluate the following integrals.

8. $F(x) = \int_1^x f(t)dt$, where $f(t) = \int_1^{t^2} \dfrac{\sqrt{1+u^4}}{u} du$. Find $F''(2)$.

9. $\int_0^4 |2x + x^2 - 3x| dx$

10. $\int x^3\sqrt{x^2+1}dx$

11. $\dfrac{d}{dx}\left(\int_{2x}^{x^2} \sqrt{t+\cos t}dt\right)$

12. $\int \tan^3(x) \quad dx$

13. $\int \frac{x^2}{1-x} dx$

*(6 pts)*14. At which points on the curve $y = 1 + 40x^3 - 3x^5$ does the tangent line have the largest slope?

*(6 pts)* 15. A kite remains 120 ft above the ground as it moves horizontally at a speed of 10 ft/sec. At what rate is the angle between the string and the ground changing when 150 ft of string have been spooled out?

*(6 pts)* 16. Find the volume of the solid obtained by rotating the region enclosed by the curves $y = \tan x$, $y = x, x = \pi/3$; about the y-axis (round to nearest hundredth).

*(6 pts)* 17. Find the amount of work required to build a cement tower in the shape of a cone that is 10 m high with a base of radius 4 m. (Density of cement is 1500 kg/m$^3$).

*(6 pts)* 18. How much work is done lifting a 20 ft chain with mass density 3 lb/ft (initially coiled on the ground) so that its top end is 30 ft above the ground.

1. $-1$
2. $5/2$
3. $1/4$
4. $e^{-2/3}$
5. $e^{2/pi}$
6. $\left(\frac{1}{x}\ln(\sin(3x+7)) + \frac{3\ln x \cdot \cos(3x+7)}{\sin(3x+7)}\right)(\sin(3x+7))^{\ln(x)}$
7. $y' = \frac{2x+4y}{\cos(y)-4x}$
8. $\sqrt{257}$
9. $86/3$
10. $\frac{1}{5}(x^2+1)^{5/2} - \frac{2}{3}(x^2+1)^{3/2}$
11. $-2\sqrt{2x+\cos(2x)} + 2x\sqrt{x^2+\cos(x^2)}$
12. $\frac{1}{2}\tan^2 x + \ln|\cos x| + C$
13. $-2(1-x)^{1/2} + \frac{4}{3}(1-x)^{3/2} - \frac{2}{5}(1-x)^{5/2} + C$
14. $(2, 225)$ and $(-2, -223)$
15. $-0.053$ rad/s
16. $0.78$
17. 6157520 Joules
18. 1200 ft-lb

Physics Challenge Questions: (WITH ANSWERS)

1. A meteoroid approaches the Earth with a trajectory that lies in the Earth's equatorial plane. In this place, let the center of the Earth be the origin of the coordinate system and let the positive x-axis point towards 0° longitude. In this coordinate system, when the meteoroid is at a position **r** = 23,000 km **y**, its velocity is given by **v** = -3500 km/s **x** + -7200 km/s **y**. At this instant,
    a. What is the tangential velocity of the meteoroid with respect to the Earth's center? (ans: -3500 km/s)
    b. What is the radial velocity of the meteoroid with respect to the Earth's center? (ans: -7200 km/s)
    c. What is the meteoroid's speed? (ans: 8 km/s)
    d. What is the meteoroid's centripetal acceleration? (ans: 2790 km/s$^2$)

2. A particle's motion in the x-direction is given by:

$$x(t) = a_o + b_o t^2 + c_o \ln\left(\frac{t}{t_o}\right)$$

    where $a_o$, $b_o$, $c_o$, and $t_o$ are all constants.

    a. What is the particle's velocity? (ans: $2b_o + c_o(1/t)$ )
    b. What is the particle's acceleration? (ans: $- c_o(1/t^2)$)

3. A disgruntled physics student throws the textbook out of a window of a tenth floor apartment, at a height of 30.0 m above street level.
    a. If the textbook was thrown at an angle of 20.0° above the horizontal at a speed of 8.00 m/s, how long does it take for the book to hit the ground? (ans: 2.77 s)
    b. How far away from the apartment building does the book land? (ans: 20.8 m)
    c. With what speed does the book hit the ground? (ans: 25.5 m/s)
    d. With what angle to the vertical does the book hit the ground? (ans: 17°)

4. A 10 gram bullet is stopped in a 5 kg block of wood that was at rest. The speed of the bullet/wood combination is 0.60 m/s immediately after the collision.
    a. What was the initial speed of the bullet? (ans: 301 m/s)
    b. How much kinetic energy was lost in this collision? (ans: 451 J)
    c. If the bullet penetrated 3 cm into the block, what was the average force exerted by the wood on the bullet to stop its motion? (ans: $1.5 \times 10^4$ N)

5. The Earth's mass is $5.98 \times 10^{24}$ kg, the Earth's radius is $6.37 \times 10^6$ m, and the orbital radius of the Earth about the Sun is $1.50 \times 10^{11}$ m. Use this data to answer the following:
    a. What is the rotational kinetic energy of the Earth? (ans: $2.57 \times 10^{29}$ J)
    b. What is the translational kinetic energy of the Earth? (ans: $2.66 \times 10^{33}$ J)

c. Which is greater, the rotational or translational kinetic energy of the Earth? (ans: translational)

6. A disk of moment of inertia I is rotating freely with angular velocity $\omega$ about a vertical axis through its center. A second disk mounted on the same shaft as the first is initially at rest. The moment of inertia of the second disk is twice that of the first. The second disk is dropped onto the first one and eventually they rotate together with the same final angular velocity.
   a. Find the final angular velocity. (ans: $\omega/3$)
   b. How much angular momentum was transferred to the second disk from the first disk? (ans: $2/3\ I\omega$)
   c. How much kinetic energy is lost during the "collision" between the two disks (when the second disk is dropped onto the first)? (ans: $-1/2\ I\omega^2$)

7. A soccer ball is kicked from level ground with a speed of *9.50 m/s* at an angle of *25.0°* above the horizontal. How long was the soccer ball in the air before it lands back on the ground? (ans: 0.819 s)

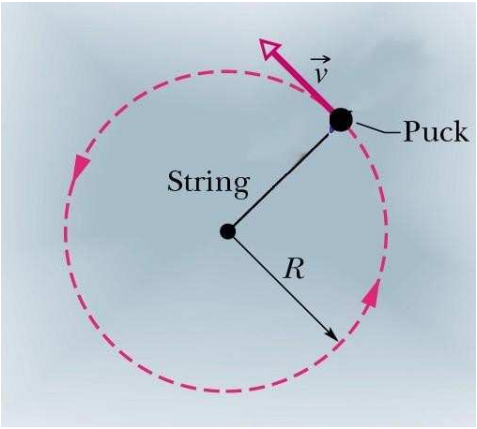
8. A physics book slides off a horizontal tabletop with a speed of 1.10 m/s. It strikes the floor in 0.350 s. Ignore air resistance.
   a. Find the height of the tabletop above the floor. (ans: 0.60 m)
   b. Find the horizontal distance from the table to the point where the book hits the floor. (ans: 0.385 m)

9. A person is trying to judge if a framed photograph (mass = 1.10 kg) is properly positioned by temporarily pressing it against a wall. The pressing force is perpendicular to the wall. The coefficient of static friction between the frame and the wall is 0.660. What is the minimum amount of pressing force that must be used? (ans: 16.3 N)

10. A truck is traveling at *11.1 m/s* down a hill when the brakes are applied. The hill makes an angle of *15°* with respect to the horizontal. The coefficient of kinetic friction between the tires and the road is *0.750*. How far does the truck skid before coming to a stop? (ans: 8.67 m)

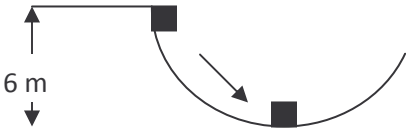
11. Two objects (45.0 kg and 21.0 kg) are connected by a massless string that passes over a massless, frictionless pulley. The pulley hangs from the ceiling.
   a. What is the acceleration of the objects? (ans: $3.56\ m/s^2$)
   b. What is the tension in the string? (ans: 281 N)

12. A small puck of mass *0.500 kg* is attached to a string of length *0.500 meters* that is fixed in position. The puck moves in a circular path on a frictionless table with a speed of *6.30 m/sec*.
   a. What is the magnitude of the puck's centripetal acceleration? (ans: $79\ m/s^2$)




b. How long does it take the puck to travel $\pi$ rad? (ans: $0.079\pi$ sec)

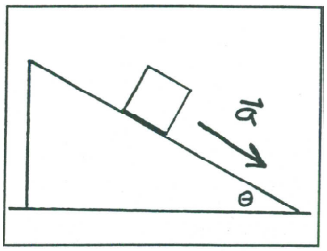
13. A *5.0 kg* package slides from rest down a portion of a circular mail chute that is *6.0 m* above the ground.




a. Calculate the velocity of the package at the bottom, assuming that the frictional force can be neglected. (ans: 10.8 m/s)
b. Calculate the normal force on the package at the bottom of the chute. (ans: 146 N)
c. Calculate the normal force on the package at the bottom of the chute if the package is at rest. (ans: 49 N)

14. A block of mass m is placed on an inclined plane as shown in the figure.

a. If the block slides down the plane with a constant speed, derive an expression relating the coefficient of kinetic friction between the block and the plane to the angle of the incline. (ans: $\mu_k = \tan(\theta)$)




b. If $\theta = 37°$ and m = 0.5 kg, what is $\mu_k$? (ans: 0.754)

c. If the coefficient of static friction $\mu_s = 0.875$, at what minimum angle would the block start sliding down on its own? (ans: 41.2°)

d. At what rate would the block accelerate with the incline at the angle calculated in part c? (ans: 0.892 $m/s^2$)

## Exam 2C—Chemistry (20 points—2 points/question)

11. A metal, M, was converted to the chloride, $MCl_2$. Then a solution of the chloride was treated with silver nitrate to give silver chloride crystals, which were filtered from the solution.

$$MCl_2\,(aq) + 2\,AgNO_3\,(aq) \rightarrow M(NO_3)_2\,(aq) + 2\,AgCl(s)$$

If 2.434g of the metal chloride gave 7.964 g of silver chloride, what is the molar mass of the metal?

12. Calculate the change in entropy when 25 kJ of energy is transferred reversibly and isothermally as heat to a large block of iron at 0 ºC?

13. Watches with numerals that "glow in the dark" were formerly made by including radioactive radium in the paint used to letter the watch faces. Assume that to make the numeral 3 on a given watch, a sample of paint containing $8.9 \times 10^{-7}$ mol of $^{228}_{88}Ra$ was used. This watch was then put in a drawer and then forgotten. Many years later someone finds the watch and wishes to know when it was made. Analyzing the paint, this person finds $1.0 \times 10^{-7}$ mol of $^{228}_{88}Ra$ in the numeral 3. How many years elapsed between the making of the watch and the finding of the watch? Consider that the half-life of $^{228}_{88}Ra$ is 6.7 years.

14. 19.50 g of Manganese (II) iodide are mixed with 16.78 g of fluorine gas and the following reaction takes place:
    a) What is the limiting reactant?
    b) How many grams of $IF_5$ will be produced?

15. Determine the complete net ionic equation for the reaction between nitric acid and copper(II) hydroxide.

16. Given the following data:

| | |
|---|---|
| Specific Heat of ice | 2.09 J/gºC |
| Heat of fusion of ice at 0ºC | 334 J/g |
| Specific Heat of liquid $H_2O$ | 4.18 J/gºC |
| Heat of vaporization of liquid water at 100ºC | 2.26 x 10 3 J/g |
| Specific Heat of steam | 2.03 J/gºC |

Calculate the amount of heat in kJ required to convert 20.0 g of ice at -40ºC to liquid water at 50.0ºC

17. The simplest formula for vitamin C is $C_3H_4O_3$. Experimental data indicates that the molecular mass of vitamin C is about 180. What is the molecular formula of vitamin C?

18. A solution of hydrochloric acid has a density of 1.12 g/ml.
    a) Find the number of grams of 750 ml of the solution, and
    b) The volume occupied by 750 g of the solution

19. Convert 86ºF to its corresponding centigrade value.

20. How many F-Te-F bond angles of different magnitudes are present in a molecule of $Tef_4$? What are the magnitudes of the angles?