5 Problems: {20,20,30,20,20} points = 110 total
4 pages including equation sheet (on page 4)

$$x''[t] + 2\beta x'[t] + \omega_0^2 x[t] == Q_0\, Exp[i\omega_D t]$$

Problem 1: (20 Pts) Given the above notation, examine the figure below, and provide as much detail as possible about what parameters were used to generate the plots below. I want to know about the initial conditions, the relative size of the pieces, and any other information you can glean from the plot. *(Hint: the first two plots have many parameters in common.)*

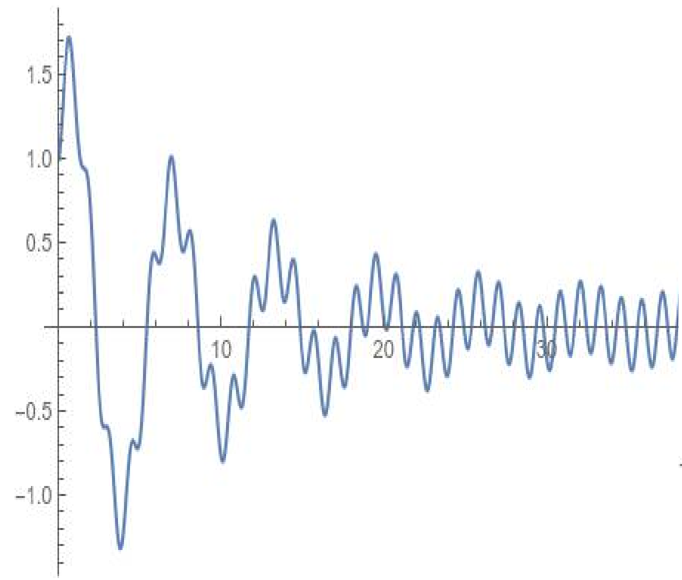


Figure 1a)

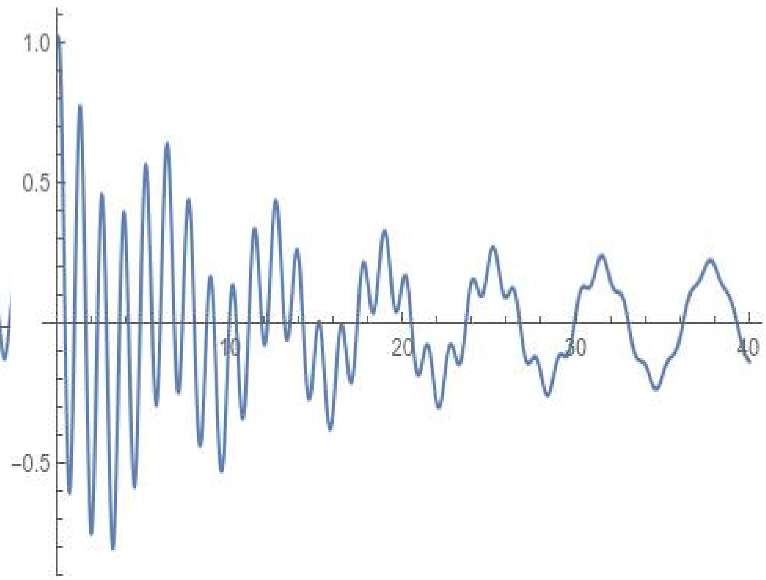


Figure 1b)

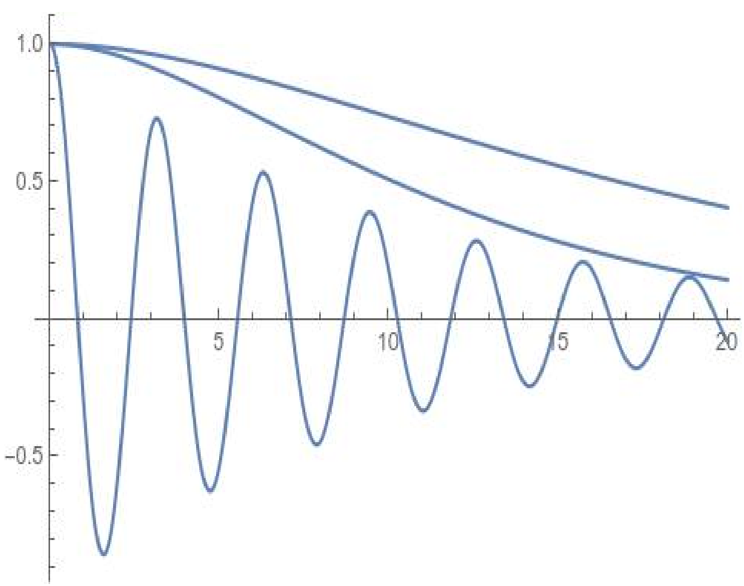


Figure 1c)

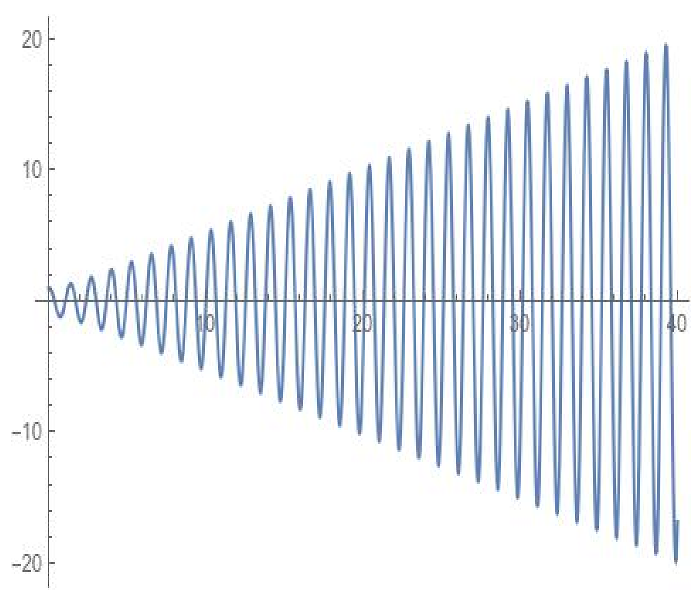
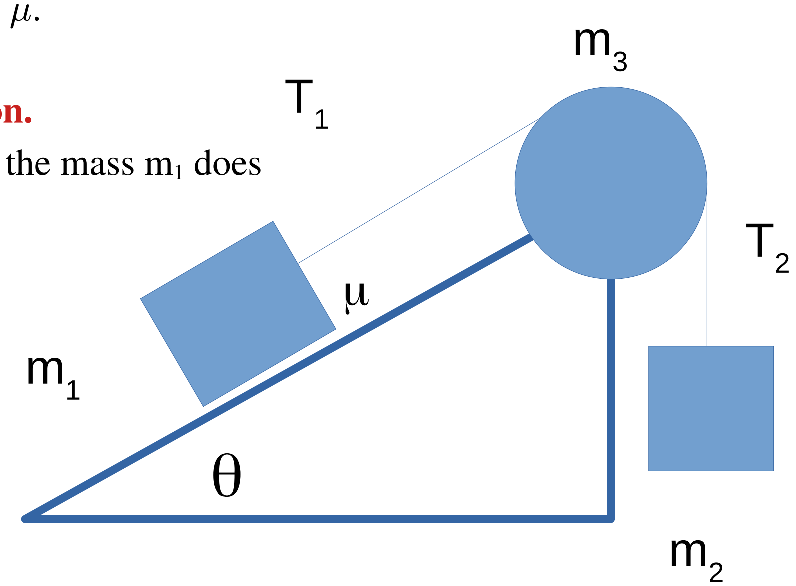


Figure 1d)

Figure 1: Hint: One of these curves is critically damped.

2a) (20 Points) Consider the system of 3 masses shown in the figure. Write down the system of equations needed to solve for the tensions and accelerations $\{T_1, T_2, a_1, a_2, \alpha_3\}$, but **DO NOT SOLVE THEM.** Assume mass m_3 has $I_3=(1/2)m_3 r^2$.
Be sure to identify equations clearly; if I can't understand your notation or writing, no credit.
Note, the ramp has friction with coefficient μ.

2b) **Now you will solve a simplified version.**
What is the minimum value of μ for which the mass m_1 does NOT slide down the ramp.
Here, I DO want you to SOLVE by eliminating $\{T_1, T_2, a_1, a_2, \alpha_3\}$ and express the answer only in terms of given quantities.
[Big hint: nothing is moving!!!]



3) (30 Pts) Consider a mass m with initial velocity v_0 in a gravitational field g and has linear air resistance (b v). **Hint: be sure to show work; no work, no points.**

a) Solve for the terminal velocity v_T.

b) Solve for the velocity v(t) in general.

Sketch a plot of v(t) for the following cases of initial velocity v_0:
[Hint: Make your plots clear enough so I can see the key points. Think about what I'm looking for.]

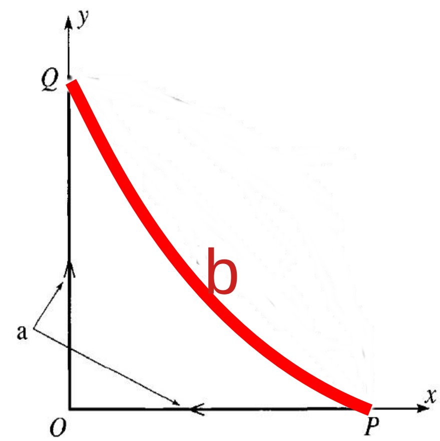
c) The objects starts with $v_0=0$.

d) The objects starts with $v_0<v_T$.

e) The objects starts with $v_0>v_T$.

f) Consider a mass m with initial velocity v_0 in a gravitational field g that has quadratic air resistance (c v^2). Solve for the terminal velocity v_T.
[Hint: I don't need a full solution, just the terminal velocity.]

4) (20 Pts) Evaluate the work done by the two-dimensional force F={2x-y, x+3y} along paths {a,b} from point P={1,0} to point Q={0,1}. **[Watch your integration limits!]**



a) Path "a" goes via the origin. [P,O,Q]

b) Path "b" is given parametrically as $x=(1-t)^2$, $y=t^3$ as t={0,1}.

c) Could this be a conservative force? Why?

5) (20 Pts) You are on Planet Hollywood of mass $m=7.35x10^{22}$Kg and radius $r=1.74x10^6$m. By coincidence, this happens to rotate once every 24 hours. Recall $G=6.67x10^{-11}$ $m^3/kg/s^2$.

a) Compute the gravitational acceleration "g" on the surface and compare to the earth (g=9.8).

b) Compute the gravitational potential energy U_G of a cannon ball on the surface of the planet that weights 1Kg.

c) You throw a cannonball from the surface and you want it to escape the gravitational pull. How fast do you need to throw it? [Assume there is NO air resistance.] That is, compute the escape velocity from the surface of Planet Hollywood. Hint: use U_G from the previous step, and remember that for it to escape it cannot have negative total energy.

d) You want to launch a satellite in orbit around Planet Hollywood so that it remains at a fixed point above the equator; this means it revolves around Planet Hollywood once every 24 hours. What is the orbital radius "r" needed.
Hint, use Newton's gravitational formula, NOT mg!

ADVANCED PLACEMENT PHYSICS 1 EQUATIONS, EFFECTIVE 2015

MECHANICS

$v_x = v_{x0} + a_x t$

$x = x_0 + v_{x0} t + \frac{1}{2} a_x t^2$

$v_x^2 = v_{x0}^2 + 2a_x (x - x_0)$

$\vec{a} = \frac{\sum \vec{F}}{m} = \frac{\vec{F}_{net}}{m}$

$|\vec{F}_f| \le \mu |\vec{F}_n|$

$a_c = \frac{v^2}{r}$

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

$\Delta\vec{p} = \vec{F}\,\Delta t$

$K = \frac{1}{2} m v^2$

$\Delta E = W = F_{\parallel} d = Fd\cos\theta$

$P = \frac{\Delta E}{\Delta t}$

$\theta = \theta_0 + \omega_0 t + \frac{1}{2}\alpha t^2$

$\omega = \omega_0 + \alpha t$

$x = A\cos(2\pi f t)$

$\vec{\alpha} = \frac{\sum \vec{\tau}}{I} = \frac{\vec{\tau}_{net}}{I}$

$\tau = r_{\perp} F = rF\sin\theta$

$L = I\omega$

$\Delta L = \tau\,\Delta t$

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

$|\vec{F}_s| = k|\vec{x}|$

$U_s = \frac{1}{2} k x^2$

$\rho = \frac{m}{V}$

a = acceleration
A = amplitude
d = distance
E = energy
f = frequency
F = force
I = rotational inertia
K = kinetic energy
k = spring constant
L = angular momentum
ℓ = length
m = mass
P = power
p = momentum
r = radius or separation
T = period
t = time
U = potential energy
V = volume
v = speed
W = work done on a system
x = position
y = height
α = angular acceleration
μ = coefficient of friction
θ = angle
ρ = density
τ = torque
ω = angular speed

$\Delta U_g = mg\,\Delta y$

$T = \frac{2\pi}{\omega} = \frac{1}{f}$

$T_s = 2\pi\sqrt{\frac{m}{k}}$

$T_p = 2\pi\sqrt{\frac{\ell}{g}}$

$|\vec{F}_g| = G\frac{m_1 m_2}{r^2}$

$\vec{g} = \frac{\vec{F}_g}{m}$

$U_G = -\frac{G m_1 m_2}{r}$

ELECTRICITY

$|\vec{F}_E| = k\left|\frac{q_1 q_2}{r^2}\right|$

$I = \frac{\Delta q}{\Delta t}$

$R = \frac{\rho\ell}{A}$

$I = \frac{\Delta V}{R}$

$P = I\,\Delta V$

$R_s = \sum_i R_i$

$\frac{1}{R_p} = \sum_i \frac{1}{R_i}$

A = area
F = force
I = current
ℓ = length
P = power
q = charge
R = resistance
r = separation
t = time
V = electric potential
ρ = resistivity

WAVES

$\lambda = \frac{v}{f}$

f = frequency
v = speed
λ = wavelength

GEOMETRY AND TRIGONOMETRY

Rectangle
$A = bh$

Triangle
$A = \frac{1}{2} bh$

Circle
$A = \pi r^2$
$C = 2\pi r$

Rectangular solid
$V = \ell w h$

Cylinder
$V = \pi r^2 \ell$
$S = 2\pi r\ell + 2\pi r^2$

Sphere
$V = \frac{4}{3}\pi r^3$
$S = 4\pi r^2$

A = area
C = circumference
V = volume
S = surface area
b = base
h = height
ℓ = length
w = width
r = radius

Right triangle
$c^2 = a^2 + b^2$
$\sin\theta = \frac{a}{c}$
$\cos\theta = \frac{b}{c}$
$\tan\theta = \frac{a}{b}$