4107 exam fall 2020

XX) A book is sliding along a horizontal desk at 1.1 m/s. It goes off the edge at time t=0, and hits the floor at time t (0.35 s). What is the height of the desk?

```
>> desk_book
h=0.5*9.8*t*t

t =  0.35000
h =  0.60025
ans = 0.60
===

t =  0.50000
h =  1.2250
ans = 1.23
===

t =  0.20000
h =  0.19600
ans = 0.20
===

t =  3.5000
h =  60.025
ans = 60.03
===

t =  4
h =  78.400
ans = 78.40
===

t =  5
h =  122.50
ans = 122.50
===
```

XX) If block **A** falls off a tower of height *Z* meters at time t=0, with v_0=0, at what vertical velocity must block **B** be thrown, at t=*T* sec, to reach the ground at the same time as block **A**?

Z= 180m
T=5s

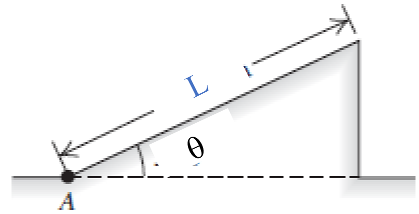
```
>> two_books
disp('check')
Z=180
td=5
g=9.8;
t=sqrt(2*Z/g);
t2=t-td;
v0=(Z-(0.5*g*t2*t2))/t2
ans = sprintf('%.1f',v0)

check
Z =  180
td =  5
v0 =  164.47
ans = 164.5
---

n =  1
Z =  170
td =  5
v0 =  186.62
ans = 186.6
---

n =  2
Z =  140
td =  3
v0 =  48.204
ans = 48.2
---

n =  3
Z =  190
td =  5
v0 =  148.84
ans = 148.8
---

n =  4
Z =  345
td =  3
v0 =  37.580
ans = 37.6
---

n =  5
Z =  343
td =  8
v0 =  933.83
ans = 933.8
---

n =  6
Z =  170
td =  0.50000
v0 =  5.1273
ans = 5.1
```

XX) A marble has a velocity of V_0 m/s. If you try to catch it with a net that has an initial velocity of v_1, and the initial separation is d, what acceleration is needed to catch it before it travels 1.2 additional m?

```
%  marble chase
clear;
n=0;
D=1.2;
v0=1.5;
d=.9;
x0=-d;
v1=0.8;
t=D/v0;
a=(2/t^2)*((D-x0)-v1*t);
ans=sprintf('%.1f',a);
param ={n,'v0,v1,d', v0, v1,d 'ans',ans}
disp('===============*****')
```

```
param =    [1]    'v0,v1,d'    [1]    [0.7000]    [0.9000]    'ans'    '1.8'

===============*****

param =  [2]    'v0,v1,d'    [1.8000]    [0.8000]    [1]    'ans'    '7.5'

===============*****

param =  [3]    'v0,v1,d'    [1.5000]    [0.9000]    [1.2000]    'ans'    '5.3'

===============*****

param =  [4]    'v0,v1,d'    [1.5000]    [1.1000]    [1.2000]    'ans'    '4.8'

===============*****

param =    [5]    'v0,v1,d'    [2]    [0.8000]    [1.5000]    'ans'    '12.3'

===============*****

param =    [6]    'v0,v1,d'    [1]    [0.8000]    [1.2000]    'ans'    '2.0'
```

XX) A sled of mass M is accelerated along a 200 m slope at 1.25 m/s^2 starting from rest at ground level. The angle of the slope is 35 degrees and the forced acceleration is replaced by the action of gravity when the sled leaves the slope.
what is the maximum height above ground reached by the sled?



Give different values of M?

```
l=200
a=1.25
deg=35
g=9.8;
theta=deg*(pi/180)
t=sqrt(2*l/a)
vy=a*sin(theta)*t;
h1=l*sin(theta);
h=0.5*(vy*vy)/g;
htot=h+h1
```

```
---
n =  1
l =  300
a =  1.2500
deg =  35
theta =  0.61087
t =  21.909
htot =  184.66
---
n =  2
l =  250
a =  1.5000
deg =  25
theta =  0.43633
t =  18.257
htot =  112.49
---
n =  3
l =  100
a =  0.75000
deg =  35
theta =  0.61087
t =  16.330
htot =  59.875
---
n =  4
l =  250
a =  1.5000
deg =  45
theta =  0.78540
t =  18.257
htot =  195.91
---
n =  5
l =  300
a =  2
deg =  30
theta =  0.52360
t =  17.321
htot =  165.31
---
n =  6
l =  400
a =  1.4000
deg =  30
theta =  0.52360
t =  23.905
htot =  214.29
```

XX) Three people are trying to push a (frictionless) box in the +x direction. Given the Forces F1 and F2,
and the angles theta 1 and theta 2, what is the magnitude of the minimum force that can be applied by
the third person to make the box move in the desired direction?

```
%vector addition
disp('check')
F1=100
F2=140
deg1=60
deg2=30
theta1=deg1*pi/180;
theta2=deg2*pi/180;
F3=-(F1*sin(theta1)-
F2*sin(theta2));
ans=abs(F3);

>> Three_forces
---
---
n =  1
F1 =  140
F2 =  140
deg1 =  60
deg2 =  30
ans1 = 51.2
---
---
n =  2
F1 =  100
F2 =  160
deg1 =  60
deg2 =  30
ans1 = 6.6
---
n =  3
F1 =  100
F2 =  140
deg1 =  45
deg2 =  30
ans1 = 0.7
---
n =  4
F1 =  100
F2 =  140
deg1 =  60
deg2 =  45
ans1 = 12.4
---
n =  5
F1 =  280
F2 =  140
deg1 =  20
deg2 =  30
ans1 = 25.8
---
n =  6
F1 =  80
F2 =  120
deg1 =  40
deg2 =  30
ans1 = 8.6
---
```

XX) An initially motionless skater on a frictionless pond has a battery powered fan strapped to her back. The fan has heavy blades, so when it starts, the blades gradually accelerate and the force it generates is a linear function of time: $F(t) = F_0\ N/s\ *t$. How far does the skater travel in the first t seconds if she weighs m kg?

```
%skater with fan
disp('check')
t=5
F0=16.8
m=45
d= t^3*16.7/(2*3*m)
ans = sprintf('%.2f',d)
disp('---')
disp('---')
```

```
>> skater_fan
---
n
= 1
t = 3
F0 = 18.600
m = 45
d = 1.8600
ans = 1.86
---
---
n = 2
t = 5
F0 = 16.800
m = 35
d = 10
ans = 10.00
---
---
n = 3
t = 7
F0 = 16.800
m = 45
d = 21.342
ans = 21.34
---
---
n = 4
t = 4.5000
F0 = 16
m = 35
d = 6.9429
ans = 6.94
---
---
n = 5
t = 4.5000
F0 = 16.800
m = 67
d = 3.8082
ans = 3.81
---
---
n = 6
t = 10
F0 = 14
m = 55
d = 42.424
ans = 42.42
---
```

XX) A truck is being used to launch a small glider, tied with a rope to the back of it. The mass of the small plane is m kg, and the friction (air and ground) may be taken as constant F_r newtons. The tension in the towline should not exceed T_{max} newtons. If the takeoff speed is v_t, what is the minimum runway length required to accelerate the glider without breaking the tow rope? (you may ignore the mass and length of the rope).

```
%k - kites
disp('check')
mk=700
Fr=2500
Tmax=12000
vt=40
a=1/(mk)*(Tmax-Fr)
d=vt^2/(2*a)
```

```
check
mk =  700
Fr =  2500
Tmax =  12000
vt =  40
a =  5
d =  160
ans = 160.00
```

===
===

n = 1
mk = 700
Fr = 200
Tmax = 2400
vt = 20
a = 3.1429
d = 63.636
ans = 63.64
===

n = 2
mk = 400
Fr = 2000
Tmax = 12000
vt = 40
a = 25
d = 32
ans = 32.00
===

n = 3
mk = 800
Fr = 2500
Tmax = 12000
vt = 60
a = 11.875
d = 151.58
ans = 151.58
===

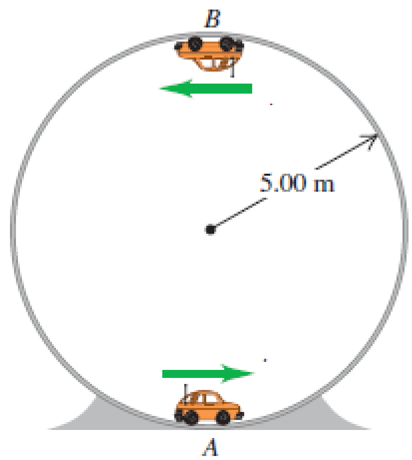
n = 4
mk = 600
Fr = 2500
Tmax = 11000
vt = 60
a = 14.167
d = 127.06
ans = 127.06
===

n = 5
mk = 600
Fr = 1200
Tmax = 12000
vt = 50
a = 18
d = 69.444
ans = 69.44
===

n = 6
mk = 300
Fr = 1000
Tmax = 12000
vt = 100
a = 36.667
d = 136.36
ans = 136.36
===

XX) An electric car with mass 0.8kg has a constant velocity as it goes around a vertical circular track. If the speed is constant, the track has a radius of 5 m, and the normal force provided by the track at the top of the loop is 6N, what is the normal force when the car is at the bottom of the loop (point A)

```
>> car_circular


n =  1
m =  0.60000
R =  5
Fn =  6
Fb =  17.760
ans = 17.8
---

n =  2
m =  0.40000
R =  5
Fn =  6
Fb =  13.840
ans = 13.8
---

n =  3
m =  0.20000
R =  5
Fn =  6
Fb =  9.9200
ans = 9.9
---

n =  4
m =  1
R =  5
Fn =  6
Fb =  25.600
ans = 25.6
---

n =  5
m =  1.2000
R =  5
Fn =  6
Fb =  29.520
ans = 29.5
---

n =  6
m =  1.2000
R =  5
Fn =  8
Fb =  31.520
ans = 31.5
```



XX) Three identical masses are attached to three identical springs.
Each spring has k= 7.8 kN/m, unstretched length d=12cm, and each mass is M=6.4 kg. What is the length of the middle spring, in cm, when the system is assembled as shown.

```
% three springs
disp('check')
g=9.8;
k=7800;
l=.12;
M=6.4;
%disp('k,l,M')
param={'k,l,M',k,l,M}
%fprintf('param=%d \n, param')
x=200*M*g/k;
lnew=l+x
fprintf('%.3f',lnew);
disp ('   ans')
```

```
>> three_springs
===
n=1
param =     'k,l,M'    [1800]    [0.1200]    [2.2000]
14.4  ans
===
n=2
param =     'k,l,M'    [7800]    [0.1200]    [4.4000]
13.1   ans
===
n=3
param =     'k,l,M'    [1800]    [0.1200]    [6.4000]
19.0   ans
===
n=4
param =     'k,l,M'    [3800]    [0.1500]    [6.4000]
18.3   ans
===
n=5
param =     'k,l,M'    [6800]    [0.1500]    [6.4000]
16.8   ans
===
n=6
param =     'k,l,M'    [800]    [0.1700]    [12.4000]
x =   30.3800
47.4   ans

===
```

XX) when a small car (700 kg) with a 75kW engine is climbing a hill, it gains altitude with a rate of 2.5 m/s. What percentage of the engine power is being used to make it climb?

```
M=700;
P=75000;
vy=2.5;
g=9.8;
ans=vy*M*g/P;
param ={n,'M,P,vy', M, P, vy, 'ans',ans}
```

car_hill_climb

check param =   [0]   'M,P,vy'   [700]   [75000]   [2.5000]   'ans'   [0.2287]

param =   [1]   'M,P,vy'   [700]   [25000]   [2.5000]   'ans'   [0.6900] **69%**

param =   [2]   'M,P,vy'   [650]   [75000]   [2.5000]   'ans'   [0.2100] **21%**

param =   [3]   'M,P,vy'   [450]   [75000]   [2.5000]   'ans'   [0.1500] **15%**

param =   [4]   'M,P,vy'   [700]   [45000]   [2.5000]   'ans'   [0.3800] **38%**

param =   [5]   'M,P,vy'   [700]   [45000]   [3.5000]   'ans'   [0.5300] **53%**

param =   [6]   'M,P,vy'   [700]   [125000]   [4.5000]   'ans'   [0.2500] **25**%

XX) A yoyo string is passed through a small hole in a Teflon (no friction) plate. The yoyo weighs 0.09 kg, and is rotating around the hole at a distance of 0.40m from the hole, with a speed of 0.7 m/s. what is the tension in the cord?

```
%yoyo string
clear;
n=0;
disp('check')
M=0.09;
r1=0.4;
v0=0.7;
v1=2.8;
r2=0.1;
ans=M*v0*v0/r1;
param ={n,'M,r1,v0', M, r1, v0, 'ans',ans}
```

```
param =     [1]    'M,r1,v0'    [0.1100]    [0.4000]    [0.4700]
'ans'    [0.0607]
ans
0.06=====

param =     [2]    'M,r1,v0'    [0.1900]    [0.2000]    [0.7000]
'ans'    [0.4655]
ans
0.47=====

param =     [3]    'M,r1,v0'    [0.2900]    [0.1400]    [0.7000]
'ans'    [1.0150]
ans
1.01=====

param =     [4]    'M,r1,v0'    [1.2000]    [0.4400]    [0.7000]
'ans'    [1.3364]
ans
1.34=====

param =     [5]    'M,r1,v0'    [0.1900]    [0.4000]    [2.7000]
'ans'    [3.4628]
ans
3.46=====

param =     [6]    'M,r1,v0'    [0.3900]    [0.2000]    [0.3700]
'ans'    [0.2670]
ans
0.27=====
```

XXb) XX) A yoyo string is passed through a small hole in a Teflon (no friction) plate. The yoyo weighs 0.09 kg, and is rotating around the hole at a distance of 0.40m from the hole, with a speed of 0.7 m/s. The cord is pulled, reducing the radius. The block is observed to have a new velocity of 2.8 m/s. How much work was done by the person who pulled on the string, in Joules?

```
%yoyo string
clear;
n=0;
disp('check')
v0=0.7;
M=0.09;
v1=2.8;%v1>v0
K1=0.5*M*v0*v0;
K2=0.5*M*v1*v1;
W=K2-K1;
param ={n,'M,v0,v1', M,v0, v1, 'W',W}
disp('ans')
fprintf('%.2f',W);
disp('=====')
```

```
param =    [1]    'M,v0,v1'    [0.1000]    [1.3000]    [2.6000]
'W'    [0.2535]
ans
0.25=====

param =    [2]    'M,v0,v1'    [0.1900]    [1.3000]    [2.8000]
'W'    [0.5842]
ans
0.58=====

param =    [3]    'M,v0,v1'    [0.1900]    [0.5000]    [2.3000]
'W'    [0.4788]
ans
0.48=====

param =    [4]    'M,v0,v1'    [0.2000]    [0.5000]    [1.8000]
'W'    [0.2990]
ans
0.30=====

param =    [5]    'M,v0,v1'    [0.3900]    [0.2000]    [2.8000]
'W'    [1.5210]
ans
1.52=====

param =    [6]    'M,v0,v1'    [0.1900]    [0.4000]    [2.8000]
'W'    [0.7296]
ans
0.73=====
>>
```

A spring (with a mass you can ignore) has force constant k. How far must it be compressed (in cm) to store U Joules of energy?

7.19

k=1600 N/m

U = 3.2 J

```
>> spring_compress
k=1600
U=3.2
x=100*sqrt(2*U/k);
ans = sprintf('%.1f',x)
====
n =  1
k =  1800
U =  38
ans = 20.5
====
n =  2
k =  20000
U =  2
ans = 1.4
====
n =  3
k =  1400
U =  4
ans = 7.6
====
n =  4
k =  1200
U =  5
ans = 9.1
====
n =  5
k =  1000
U =  2
ans = 6.3
====
n =  6
k =  1600
U =  5.3100
ans = 8.1
```

7.19b

A spring with spring constant k has a book of mass m dropped on it from a height of h meters above the end of the spring. How far does it compress (in m) (maximum compression, ignore weight of spring)

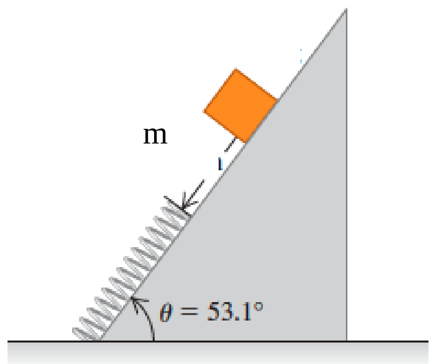
k=1600
m=1.2kg
h=0.8
initial energy is mg(h+x), final is ½ kx^2

```
%spring compress gravity
disp('check')
k=1600
m=1.2
h=0.8
g=9.8;
a=k/2;
b=-m*g;
c=-m*g*h;
x=(-b+sqrt(b*b-4*a*c))/(2*a);
x2=(-b-sqrt(b*b-4*a*c))/(2*a);
ans = sprintf('%.2f',x)
```

```
---
n =  1
k =  1000
m =  1.2000
h =  0.90000
ans = 0.16
---
n =  2
k =  1200
m =  1.2000
h =  1.8000
ans = 0.20
---
n =  3
k =  2100
m =  2
h =  0.80000
ans = 0.13
---
n =  4
k =  1900
m =  1
h =  0.90000
ans = 0.10
---
n =  5
k =  2500
m =  1
h =  0.80000
ans = 0.08
---
n =  6
k =  2300
m =  2
h =  1
ans = 0.14
```

XX) A block of mass *m* is on a frictional slope with a coefficients of friction of μ_k =0.2, and μ_s = $2*\mu_k$. The mass of the spring can be ignored. The block is let go from a distance of *D* meters above the spring along a slope of *theta* degrees to the horizontal (figure)

What is the maximum compression of the spring?




```
clear;
disp ('check')
deg=53
theta = pi/180*deg;
g=9.8;
muk =0.2
m=2.0
k=120
d=4.0
% quadratic coefficients

b=m*g*sin(theta) - muk*m*g*cos(theta);
c=-d*(m*g*sin(theta)-m*g*muk*cos(theta));
x=(-b+sqrt(b*b-4*a*c))/(2*a)
x2=(-b-sqrt(b*b-4*a*c))/(2*a)
ans = sprintf('%.2f',-x2)
disp('---')

>> bridg
---
n =  1
deg =  52
muk =  0.30000
m =  4
k =  120
d =  4
x =  1.0739
x2 = -1.4681
ans = 1.47
---
---
n =  2
deg =  60
muk =  0.20000
m =  4
k =  120
d =  4
x =  1.1866
x2 = -1.6871
ans = 1.69
---
---
---
n =  3
deg =  73
muk =  0.20000
m =  2
k =  120
d =  5
x =  1.0732
x2 = -1.3665
ans = 1.37
---
---
n =  4
deg =  51
muk =  0.20000
m =  2
k =  100
d =  1.5000
x =  0.50421
x2 = -0.75951
ans = 0.76
---
---
n =  5
deg =  45
muk =  0.10000
m =  2
k =  120
d =  6
x =  1.0177
x2 = -1.2256
ans = 1.23
---
---
n =  6
deg =  60
muk =  0.15000
m =  2
k =  120
d =  4
x =  0.89564
x2 = -1.1540
ans = 1.15
---
```

XX) 7.63 (class example)
A sled is stationary on a cylinder of ice, and starts sliding down from the top. Assuming no friction, at what distance from the top does the sled lose contact with the surface?
The cylinder radius is R, and is on a moon with a gravitational acceleration given by g, and the mass of the object is m.

answer is 48.2 degrees independent of R, g and m, so distance is R * theta in radians

```
% sled on cylinder
R= [10,8,6,4,2,9,12]
deg=48.2
rad= deg*pi/180
distance =R*rad

R = 10    8    6    4    2   12

deg =  48.200
rad =  0.84125
distance =

    8.4    6.7    5.    3.4   1.7   10.
```

========

8.21

XX) On a flat, frictionless pond there are two small curling stones with (energy conserving) bouncy rings around them. Stone A (mass m_A) is moving toward stone B, initially at rest, which has mass m_B.

After the collision, stone A has velocity v1 to the left and B has velocity v2 to the right.

what was the speed of stone A before the collision?

curling_stones

```
ma=0.25
mb= 0.35
v1=-.12
v2=.65
va=(ma*v1 + mb*v2)/ma
```

===
n = 1
ma = 0.20000
mb = 0.40000
v1 = -0.12000
v2 = 0.65000
va = 1.1800
ans = 1.18
===
n = 2
ma = 0.15000
mb = 0.35000
v1 = -0.12000
v2 = 0.65000
va = 1.3967
ans = 1.40
===
n = 3
ma = 0.25000
mb = 0.35000
v1 = -0.18000
v2 = 0.65000
va = 0.73000
ans = 0.73
===
n = 4
ma = 0.25000
mb = 0.35000
v1 = -0.12000
v2 = 0.50000
va = 0.58000
ans = 0.58
===
n = 5
ma = 0.25000
mb = 0.30000
v1 = -0.12000
v2 = 0.50000
va = 0.48000
ans = 0.48
===
n = 6
ma = 0.25000
mb = 0.50000
v1 = -0.18000
v2 = 0.65000
va = 1.1200
ans = 1.12
===

A block of mass m2 is hanging (at rest) from a thin wire that is L meters long. It is hit by modeling clay of mass m1 that sticks to the block. What is the minimum initial speed of the clay that will cause the block to travel in a circular loop?
m1=20kg
m2=5 kg
L= 3.5

conservation of momentum gives v', KE has to be enough to give PE plus v^2/R that matches gravity

```
% clay hits block
n=0 %check
m2=20
m1=5
L=3.5
g=9.8;
m=m1+m2;
v3=sqrt(g*L);
PE=2*m*g;
v2=sqrt(v3^2+4*g*L)
v1=(m/m1)*v2;
ans = sprintf('%.0f',v1)
disp('====')

>> block_clay
n = 0
m2 =  20
m1 =  5
L =  3.5000
v2 =  13.096
ans = 65  (v1)
====
n =  1
m2 =  10
m1 =  5
L =  3
v1 =  36.373
ans = 36
====
n =  2
m2 =  21
m1 =  2
L =  3.5000
v1 =  150.60
ans = 151
====
n =  3
m2 =  30
m1 =  4
L =  3.5000
v1 =  111.31
ans = 111
====
n =  4
m2 =  20
m1 =  2
L =  3
v1 =  133.37
ans = 133
====
n =  5
m2 =  10
m1 =  6
L =  32
v1 =  105.59
ans = 106
====
n =  6
m2 =  40
m1 =  5
L =  3.5000
v1 =  117.86
ans = 118
=
```

A uniform spherical ball is rotating around its axis (a line that coincides with the diameter). The mass of the ball is M kg, the radius is r, and the rotational kinetic energy is KE. What is the tangential velocity of a point at the 'equator' of the surface?

M=28
r=0.38
KE = 176

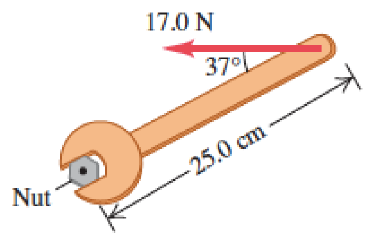
```
>> sphere_surf_vel
 sphere surface velocity
n=0
M=28
r=0.38
KE=176
I=2*M*r^2/5;
w=sqrt(2*KE/I);
vt=w*r;
ans = sprintf('%.1f',vt)
disp('=======')

n = 0
M =  28
r =  0.38000
KE =  176
ans = 5.6
=======
n =  1
M =  20
r =  0.40000
KE =  175
ans = 6.6
=======
n =  2
M =  222
r =  0.30000
KE =  150
ans = 1.8
=======
n =  3
M =  13
r =  0.50000
KE =  142
ans = 7.4
=======
n =  4
M =  24
r =  0.70000
KE =  110
ans = 4.8
=======
n =  5
M =  22
r =  0.50000
KE =  150
ans = 5.8
=======
n =  6
M =  10
r =  0.90000
KE =  140
ans = 8.4
=======
>
```

A spherical ball of density rho1 is coated with a thin layer of *area* density sigma. What is the moment of inertia of the coated ball? The radius of the ball is 0.3m, and rotation is about the axis of the sphere
rho1= 800kg/m^3
sigma=20 kg/m^2

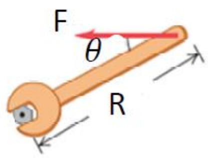
```
% foil coated ball
n=0
rho1=800 %kg/m^3
sigma=20 %kg/m^2
r=0.3
V=4/3*pi*r^3;
mb=rho1*V;
mf=4*pi*r^2*sigma;
I=((2/5)*mb*r^2)+((2/3)*mf*r^2);
ans = sprintf('%.1f',I) ; % kg-m^2
disp ('========')
```

```
>> foil_sphere


========
n =  1
rho1 =  400
sigma =  20
r =  0.30000
ans = 3.0
========
n =  2
rho1 =  800
sigma =  10
r =  0.30000
ans = 3.9
========
n =  3
rho1 =  800
sigma =  12
r =  0.30000
ans = 4.1
========
n =  4
rho1 =  222
sigma =  20
r =  0.30000
ans = 2.3
========
n =  5
rho1 =  80
sigma =  20
r =  0.30000
ans = 1.7
========
n =  6
rho1 =  800
sigma =  60
r =  0.30000
ans = 7.3
========
```

A professor is using a wrench to tighten a nut. the wrench is R meters long, and she pushes with F newtons of force, at an angle of theta degrees with respect to the radial direction. What torque does she apply around the center of the nut? (the distance from the center of the nut to the flat faces is r)



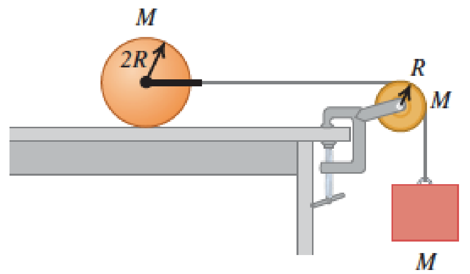
R=.25
r=.010
F=17
theta = 37




```
>> wrench_torque
% torque with wrench
n=0
R=.25
r=.01
F=17
thet=37
theta=pi*thet/180;
tau=R*F*sin(theta); %N-m
ans = sprintf('%.2f',tau)
```

```
+++++
n =  1
R =  0.50000
r =  0.010000
F =  17
thet =  37
ans = 5.12
+++++
n =  2
R =  0.25000
F =  12
thet =  37
ans = 1.81
+++++
n =  3
R =  0.20000
F =  17
thet =  25
ans = 1.44
+++++
n =  4
R =  0.25000
F =  25
thet =  30
ans = 3.12
+++++
n =  5
R =  0.30000
F =  22
thet =  45
ans = 4.67
+++++
n =  6
R =  0.22000
F =  14
thet =  32
ans = 1.63
+++++
```

A solid cylinder (Mass M, radius 2R) has a rope attached to a rod through its axis (an axle) that has no friction so that the cylinder can roll. The rope runs over a cylindrical pulley (mass M, radius R) with a similar frictionless axle, and a mass M is attached to the end of the rope. The large cylinder doesn't slip on the bench, and the string doesn't slip on the pulley. What is the acceleration of the block if initially motionless?



a=g/6
a=g/5
a=g/4
a=g/3
a= 2g/5
a = 2g/3

A ball of mass m is hanging from a near-weightless spring and is pulled d meters below its equilibrium position. It oscillates with a period of T seconds. what is its speed as it passes through the equilibrium position again?

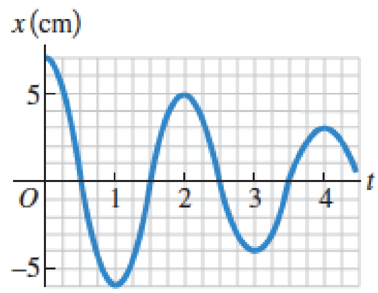
m=5
d=0.1
T= 4.2

```
>> oscillating_vel
% oscillating mass
n=0
m=5
A=0.1
T=4.2
vx=2*pi*A/T;
ans = sprintf('%.2f',vx)

++++
n =  1
m =  10
A =  0.10000
T =  5
ans = 0.13
++++
n =  2
m =  15
A =  0.40000
T =  4.2000
ans = 0.60
++++
n =  3
m =  20
A =  1.2000
T =  4
ans = 1.88
++++
n =  4
m =  25
A =  0.80000
T =  6
ans = 0.84
++++
n =  5
m =  35
A =  1.2000
T =  1.5000
ans = 5.03
++++
n =  6
m =  30
A =  0.30000
T =  5.4000
ans = 0.35
```

A mass of mass m is attached to a spring with force constant k, and set in motion, resulting in oscillations as shown in the graph, which plots the solution to

calculate m and then determine the damping constant b. (use resonance freq to get m, then values at 0 and 4 seconds to get b/2m, hence b

$$-kx - b\frac{dx}{dt} = m\frac{d^2x}{dt^2}$$




```
>> damped_spring
% spring losing energy?
clear;
n=1
f=.5;
k=255
m= k/(pi*pi) %(2*pi*f)^2 where f is 0.5 from the graph
b=-.5*m*log(3/7)
ans = sprintf('%.2f',b)
disp('++++')
```

```
n =  1
k =  255
m =  25.837
b =  10.946
ans = 10.95
++++
n =  2
k =  200
m =  20.264
b =  8.5849
ans = 8.58
++++
n =  3
k =  300
m =  30.396
b =  12.877
ans = 12.88
++++
n =  4
k =  40
m =  4.0528
b =  1.7170
ans = 1.72
++++
n =  5
k =  16
m =  1.6211
b =  0.68679
ans = 0.69
++++
n =  6
k =  20
m =  2.0264
b =  0.85849
ans = 0.86
++++
>>
```

A boat is moving periodically up and down due to waves at the surface. The time to get from the crest (high point) to the trough (low point) is *t*, and the vertical distance is h. The lateral distance between the crests is L. what is the velocity of the waves?

t= 2.5s (this is half of period)
L=6 m
h=0.6 (A=0.3)
v=L/T

```
>> wave_vel
% wave velocity
n=0
t=2.5
L=6
h=.06
v=L/(2*t)
ans = sprintf('%.1f',v)
disp('-----')
```

```
-----
n =  1
t =  5
L =  6
h =  0.060000
v =  0.60000
ans = 0.6
-----
n =  2
t =  22
L =  6
h =  0.060000
v =  0.13636
ans = 0.1
-----
n =  3
t =  4
L =  12
h =  0.060000
v =  1.5000
ans = 1.5
-----
n =  4
t =  2.5000
L =  18
h =  0.060000
v =  3.6000
ans = 3.6
-----
n =  5
t =  2.5000
L =  12
h =  0.060000
v =  2.4000
ans = 2.4
-----
n =  6
t =  4
L =  6
h =  0.060000
v =  0.75000
ans = 0.8
-----
```

A string instrument is to be tuned to a frequency, *f*. The length of the string is L, and this will be the fundamental. The mass of the string is m. What tension must be applied?

f=65..4/s

L= 0.6m

m = 14.4 g

```
% string fundamental
clear;
n=0
f=65.4
L=0.6
mg=14.4
m=mg*.001;
mu=m/L;
lambda=L*2;
v=lambda*f;
F=mu*v^2'
ans = sprintf('%.1f',F)
disp('-----')
```

```
>> tune_string


n =  1
f =  65
L =  0.70000
mg =  14
F =  165.62
ans = 166
-----
n =  2
f =  70
L =  0.50000
mg =  12
F =  117.60
ans = 118
-----
n =  3
f =  70
L =  0.60000
mg =  20
F =  235.20
ans = 235
-----
n =  4
f =  120
L =  0.60000
mg =  12
F =  414.72
ans = 415
-----
n =  5
f =  240
L =  0.60000
mg =  6
F =  829.44
ans = 829
-----
n =  6
f =  440
L =  0.20000
mg =  8
F =  1239.0
ans = 1239
-----
```