# Physics Final

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## 1 Orbits

Angular velocity: W = $\frac{\theta}{t}$

W = $\frac{2\pi}{t}$

W in units rad/sec

Record turns at 33 rev/min; W in rad/sec; Ant is sitting 5 cm from the center of the record; Velocity in m/s

W = $\frac{2\pi\times33}{60} = 3.46$rad/s

$3.46\ rad/s \times \frac{2\pi(0.05)^2}{2\pi} = 1.73$m/s

Centripetal acceleration: a force that causes an object to accelerate centripetally, therefore moving in a circle

Loop: 2m; Person: 70kg; Minimum speed for no fall

Fg = mg = 70 $\times 9.8 = 686N$

$mg = \frac{mv^2}{r}$

v = $\sqrt{rg} = \sqrt{2\times 9.8}$

v = $\sqrt{19.6} = 4.43m/s$

a = $\frac{V^2}{R}$

Tangential speed: v = Wr

F$_g = \frac{mMG}{r^2}$

F$_g = mg = \frac{mv^2}{R}$

-PE = $\frac{-mMG}{r}$

KE = $\frac{mMG}{2r}$

a = $\frac{MG}{r^2}$

$\frac{1}{2}mv^2 = \frac{mMG}{r}$

Kepler's 3rd Law: v$^2 = \frac{GM}{r}; v^2 = \frac{4\pi^2r^2}{{T_{period}}^2}$

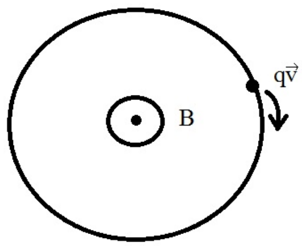
Launch velocity for circular orbit:

$$v = \sqrt{aR}$$

Launch velocity for escape:

$$v = \sqrt{\frac{2MG}{r}}$$

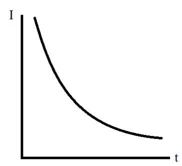
Lowest rotational energy: I $= \text{mr}^2 + mr^2$
Lowest: $\frac{IW_{min}}{Inertia}$

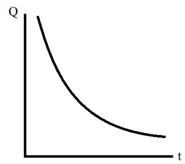



Find the radius of the circle
$\text{F}_B = q_v B$
$\text{F}_{net} = ma$
$\text{q}_v B = \frac{mv^2}{R}$
$R = \frac{mv^2}{q_v B}$
$R = \frac{mv}{qB}$

## 2 Electricity and Electromagnetism

$\text{Current}_{in}$ = clockwise
$\text{Current}_{out}$ = counterclockwise
If magnetic field (B) and current (I) are in same direction, no force
Right hand rule: thumb - motion; index finger - magnetic field; middle finger - current
$\text{F}_E = \frac{qQK_E}{r^2}$
E $= \frac{Qk_e}{r^2}$
PE $= \frac{qQk_e}{r}$
V $= \frac{Qk_e}{r}$
E $= \frac{-\Delta V}{\Delta x}$
Capacitor:
I $= \frac{\Delta Q}{\Delta T}$






Separation between two points:

$$-\Delta x = \frac{\Delta v}{E}$$

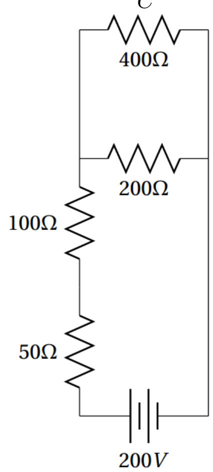
Force of electric field on a charge:

$$F = Eq$$

Change in PE:

$$PE = Vq$$

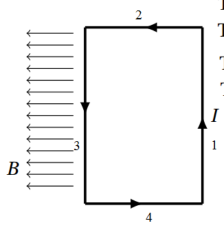
Power $= \frac{\Delta energy}{time}$
$F_B = q_v B$
$q_v B = qE$
Magnetic field: $\frac{E}{V}$
E$\Delta x = \Delta V$
$1Volt = \frac{Nm}{C} = \frac{kgm^2}{Cs^2}$




Equivalent resistance of the circuit; Current through the 50Ω resistor; Current through the 200Ω resistor; Voltage drop across the 100Ω resistor; Power dissipated by the 400Ω resistor

a. R = 100 + 50 = 150
$\frac{1}{R_p} = \frac{1}{400} + \frac{1}{200} = \frac{3}{400}$
R $= 150 + \frac{400}{3} = 283.3\Omega$

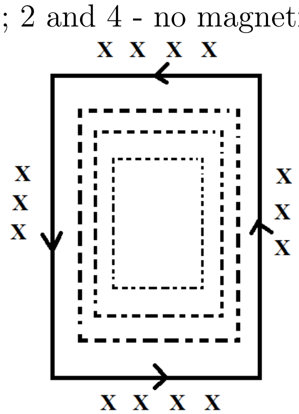
b. I $= \frac{V}{R} = \frac{200}{283.3} = 0.706A$
c. V = IR = 0.706 $\times 150 = 105.88V$
$V_R = 200 - 105.88 = 94.12V$
$\frac{94.12}{200} = 0.471A$
d. $V_{100} = IR = 0.706 \times 100 = 70.6V$
e. $I_{400} = \frac{94.12}{400} = 0.2353A$
P = IV = 0.2353 $\times 94.12 = 22.15W$




The loop is a 4x6 cm rectangle.
The wire contains $10^{18}$ free moving electrons.
The magnetic field is $B = 0.050$ Tesla.
The current is $I = 1.6$ Amperes.

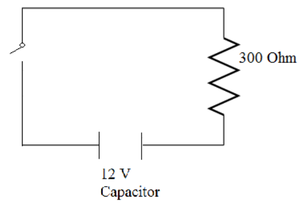
Direction of magnetic force on each section of the loop; Magnitude of force on each section; Structure of magnetic field created by loop; Subsequent motion of the loop if free to move

a. 1) Direction of magnetic force - outside
2) and 4) No magnetic force
3) Direction of magnetic force - inside
b. T $= \frac{Q}{I} = \frac{10^{18} \times 1.6 \times 10^{-19}}{1.6} = 0.1s$
V $= \frac{S}{T} = \frac{0.2}{0.1} = 2m/s$
$F_B = q_v B = 10^{18} \times 1.6 \times 10^{-19} \times 2m/s \times 0.05T = 0.016N$(for 1 and 3; 2 and 4 - no magnetic force)

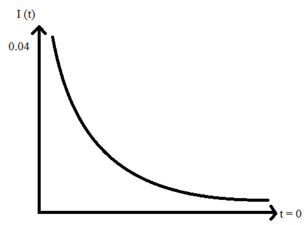
c. 


d. The left side will go in; the right side will go out

Capacitor: 60 $\times 10^{-3}$C with 12 V of potential. The capacitor is connected in series with a 30 $\Omega$ resistor. The resistor begins discharing at t = 0.




Graph as a function of time, I(t). Value of initial current.




$I = \frac{V}{R} = \frac{12}{300} = 0.04A$

How capacitor functions as a battery: There is electric field in the capacitor so it can push charge to create current.

The voltage in the capacitor will focus on the resistor, which will cause current flow.

Displacement current will generate a B field.

How parallel wires in opposite directions can define the Ampere:

Both Is are the same because they do not need to consider direction since they are in opposite directions. Therefore, the directions of the $F_B$ are opposite and the two wires attract.

## 3 Torques

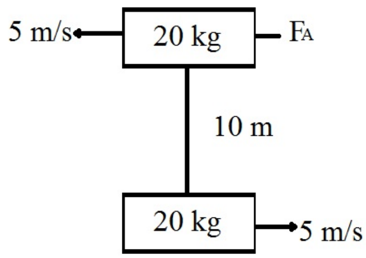
$\tau = rFsin\Delta\theta$

Clockwise - negative

Counterclockwise - positive

I $= \sigma mr^2$

Angular acceleration: $\propto = \frac{\Delta w}{\Delta t}$




Find the W of rotation and the $F_A$ required to stop the rotation in 10 seconds

W $= \frac{V}{r} = \frac{5m/s}{5m} = 1rad/s$

$W_i = 1rad/s$

$W_f = 0rad/s$

$\Delta w = -1rad/s$

Angular acceleration: $\frac{\Delta w}{\Delta t} = \frac{-1rad/s}{10s} = -0.1rad/s$

$\tau_{net} = I \propto$

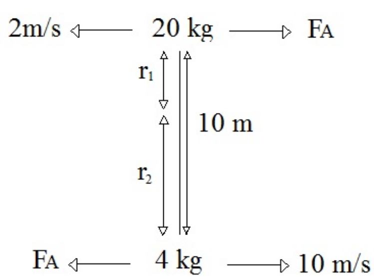
I $= \sigma mr^2 = 20(5)^2 + 20(5)^2 = 1000$ kgm$^2$

$\tau_{net} = 10000 \times -0.1 = 100$ Nm clockwise

$5 \times F_A = 10F_A = 100$ Nm

$F_A = 10N$

$\tau_{net} = 10F_A$




Calculate W if it rotates around the center; determine the point around which the masses around; make sure $W_{20kg} = W_{4kg}$; find F to stop the rotation in 10 s

Top: W $= \frac{V}{r} = \frac{2}{5} = 0.4rad/s$

Bottom: W $= \frac{V}{r} = \frac{10}{5} = 2rad/s$

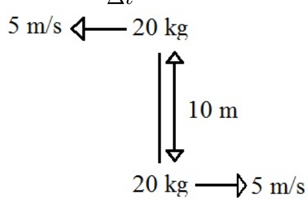
$\frac{2}{r_1} = \frac{10}{r_2}$

$r_1 = r_2 = 10$

$2r_2 = 10r_1$

$r_2 = 5(10 - r_2)$

$r_2 = 50 - 5r_2$
$6r_2 = 50$
$r_2 = 8.33m$
$W = \frac{10}{8.33} = 1.2rad/s$
$W_I = 1.2rad/s$
$\Delta W = -1.2rad/s$
$\propto = \frac{-1.2rad/s}{10s} = -0.12rad/s^2$
$\tau_{net} = I \propto$
$I = \sigma mr^2 = m_1r_1^2 + m_2r_2^2 = 20(1.67)^2 + 4(8.3)^2 = 333.33$ kgm$^2$
$333.33 \times 0.12 = 40$ Nm
$F_A \times 10 = 40$ Nm
$F_A = 4NKE_{rot} = \frac{IW^2}{2}$
Angular Momentum: l $=$rpsin $\theta$
$F_{net} = \frac{\Delta p}{\Delta t}$

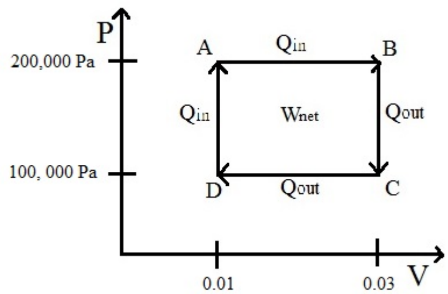



Find angular momentum around the end and the center; Shorten the rope from 10m to 5m; Describe resulting motion
a. $l_{top} = 10(100) = 1000kgm^2/s$
$l_{middle} = 5(100) + 5(100) = 1000kgm^2/s$
Angular momentum is conserved

## 4 Thermodynamics

Kinetic Theory
Monatomic: KE $=\frac{3}{2}K_BT$
$\frac{mv^2}{2} = \frac{3}{2}k_BT$
Diatomic: KE $=\frac{5}{2}$ $K_BT$
$\frac{mv^2}{2} = \frac{3k_BT}{2}$
$\frac{IW^2}{2} = \frac{2k_BT}{2}$
Find the kinetic energy of $O_2$ at 294 K and determine the translational speed of each molecule
$\frac{5}{2}k_BT = \frac{5}{2} \times 1.38 \times 10^{-23}(294)$
$KE_{trans} + KE_{rot} = \frac{3}{2}k_BT + \frac{2}{2}k_BT$

KE$_{trans} = \frac{1}{2}mv^2 = 0.61 \times 10^{-20}J$
$\frac{1}{2}(16mp)v^2 = 0.61 \times 10^{-20}J$
$vr = \frac{0.61\times10^{-20}}{8(1.7\times10^{-27})} = 448529$
v = $670\ m/s$
U = mCT
$\Delta v = mc\Delta T$
$\Delta U = mC_p\Delta T$
$\Delta U = mL$
E = $\frac{W}{Q_{in}}$




E = $\frac{work}{Q_{in}}$
$\Delta U = Q - W$
$\Delta U = Q - P\Delta W$
U = $\frac{3}{2}PV$
Q = $\Delta U + P\Delta V$
D: U = $\frac{3}{2}PV = \frac{3}{2} \times 10^5 \times 10^{-2} = 1.5 \times 10^{-3}$
A: U = $\frac{3}{2}PV = \frac{3}{2} \times 2 \times 10^5 \times 10^{-2} = 3 \times 10^3$
B: U = $\frac{3}{2}PV = \frac{3}{2} \times 2 \times 10^{-2} = 9 \times 10^3$
Total Q$_{in} = 11.5 \times 10^3 J$
Work out = 2 $\times 10^3 J$
From D to A: $\Delta V = 1.5 \times 10^3; Q_h = 1.5 \times 10^3$
From A to B: $\Delta V = 6 \times 10^3; Q_h = 10 \times 10^3$
W = P$\Delta V = 2 \times 10^{-2} = 4 \times 10^3$
$\Delta U = Q + W$
At B: T = $\frac{PV}{nR} = \frac{(2\times10^5)(3\times10^{-2})}{1(8.31)}$
T$_h = \frac{5000}{8.31} = 7.22K$
T$_{low} = \frac{PV}{nR} = \frac{(1\times12^5)(1\times10^{-2})}{nR} = \frac{1000}{8.31}$
T$_{low} = 120$
E$_c = \frac{T_h - T_c}{T_h} = \frac{722-120}{722} = 83\%$
W = work on gas

Q = heat into gas

Entropy: $\Delta S = \frac{Q}{T}$

2 kg of ice at 0 degrees Celsius turns into liquid at 10 degrees Celsius

Find $\Delta S$

$\Delta S = \frac{Q_{melt}}{T} + \frac{Q_{heat}}{T} = \frac{mL}{273} + \frac{mC_p \times 10}{278}$