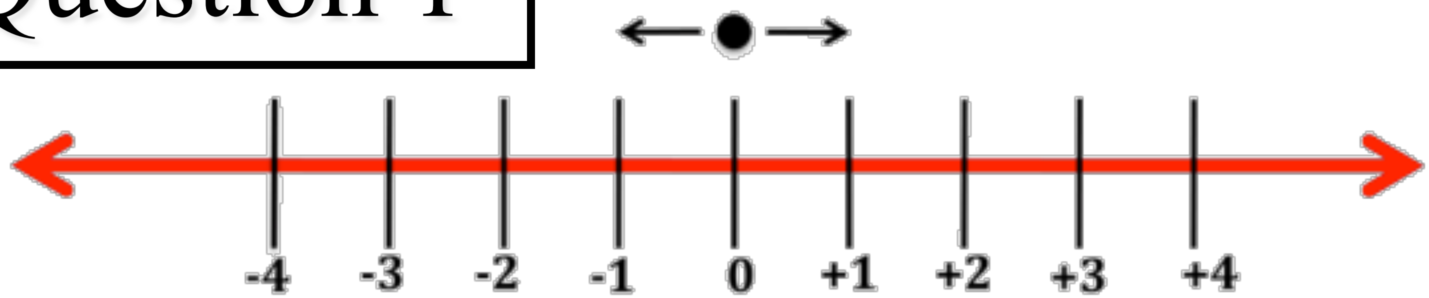
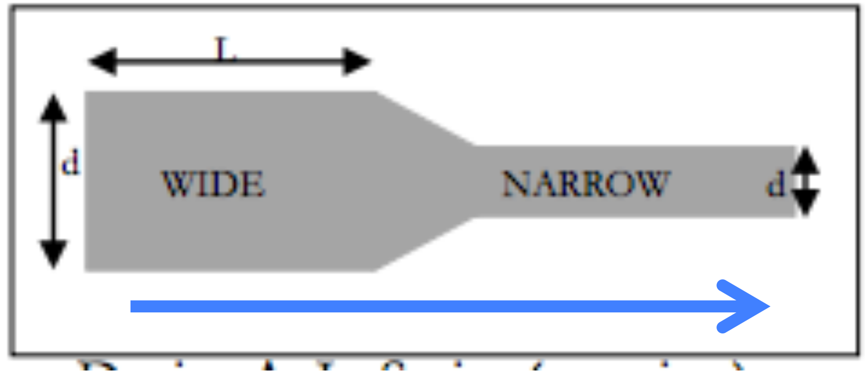
Q3 Question 1



A marker in a game is constrained to move along a one-dimensional grid. It begins at 0 and moves according to a coin flip: left for heads, right for tails. After 3 flips it will be either 1 step away from its starting point or 3. How much more likely is it to be 1 step away than 3 steps? (3 pts)

A. They are equally probable.
B. 3 steps away is three times as probable as 1 step.
C. 1 step away is three times as probable as 3 steps.
D. None of these are correct.

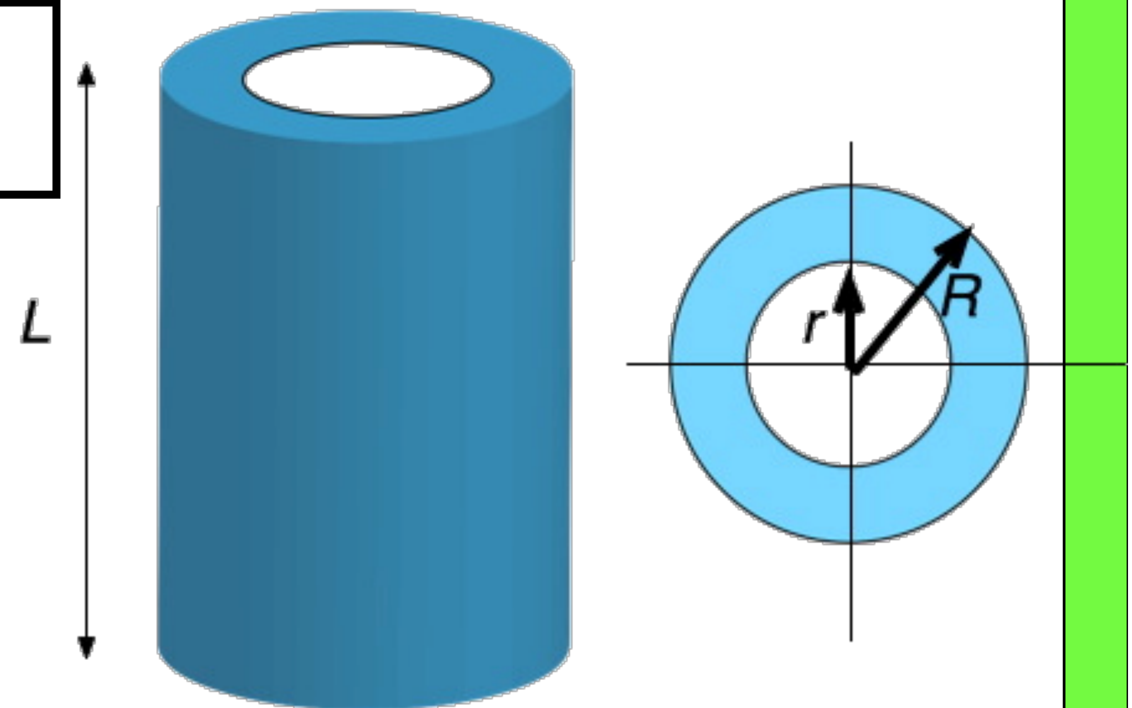
Q3 Question 2



Fluid is flowing in the direction indicated by the blue arrow through a channel that has a wide and a narrow part in series. Is the volume of fluid crossing a plane perpendicular to the flow greater in the wide (W) or narrow (N) part? Is the speed of flow greater in the wide (W) or narrow (N) part? (3 pts)

A. Flow greater in W, speed greater in W.
B. Flow greater in W, speed greater in N.
C. Flow greater in N, speed greater in W.
D. Flow greater in N, speed greater in N.
E. **Flow same in both, speed greater in N.**
F. Flow same in both, speed greater in W.
G. Speed same in both, flow greater in N.
H. Speed same in both, flow greater in W.

Q3 Question 3



Which is the appropriate formula to use for the volume of a circular pipe given the indicated measurements? (2 pts)

A. $V = 2\pi rRL$

B. $\boxed{V = \pi(R^2 - r^2)L}$

C. $V = \pi(R^2 + r^2)L$

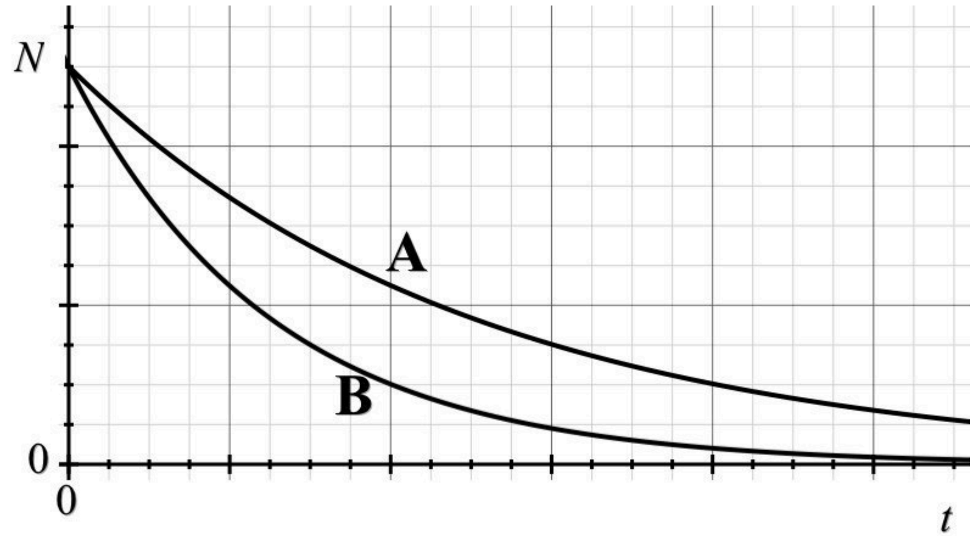
D. $V = \pi(R - r)^2 L$

E. None of these work

Q3 Question 4

The number of atoms of a radioactive element decreases like

$$N(t) = N_0 e^{-\beta t}$$



where N_0 is the number of atoms at time $t = 0$ and β is a parameter with units of inverse time. Two radioactive materials start at $t = 0$ with the same number of atoms. The graphs show how their numbers fall. Which element has the larger value of β? (2 pts)

A. A

B. B

C. They are the same

Suppose we consider energy as not in packets but as continuous. If a system is in thermal equilibrium then:

A. Each degree of freedom will contain the same amount of energy since the equilibrium occurs at maximum entropy and the highest entropy state is when energy is maximally shared.
B. At any instant of time we expect that different degrees of freedom will contain different amounts of energy.
C. There is not enough information to tell.

Suppose we have a system with N degrees of freedom and an amount of energy U. How many different ways are there of putting the same amount of energy in each ($= U/N$).

A. 1

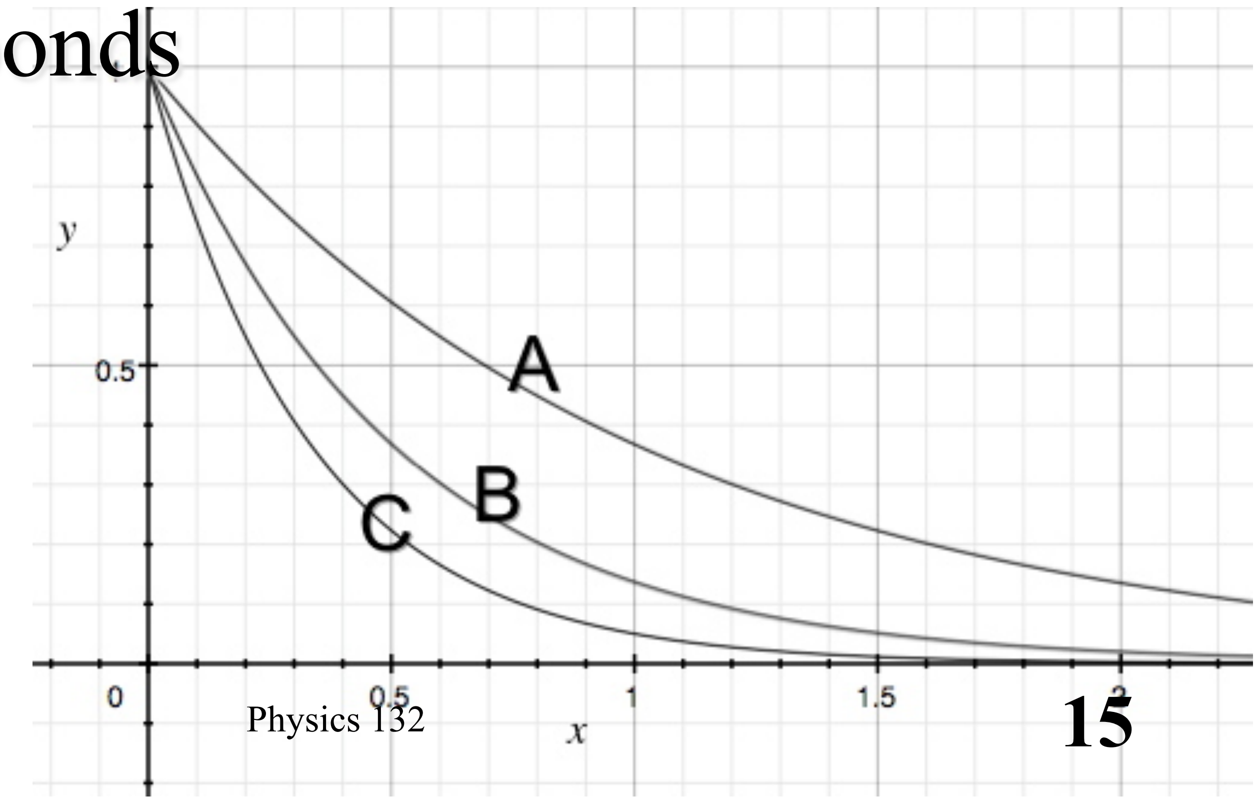
B. N

C. N!

D. N^N

E. Something else.

The Boltzmann factor, $e^{-\frac{\Delta E}{k_B T}}$, is proportional to the probability that a DoF will gain an energy ΔE from its interaction with a thermal bath. Which of the graphs of these **exponential factors** corresponds to the highest value of T?

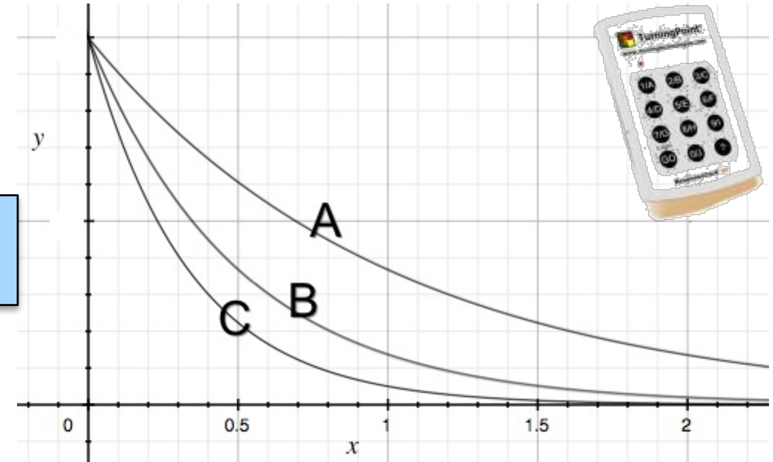


In the Boltzmann factor, $e^{-\frac{\Delta E}{k_B T}}$,
the dependence on "T" tells you that:

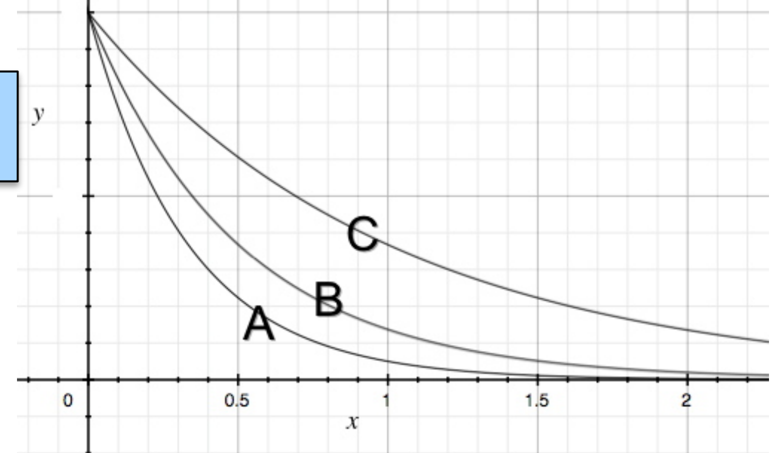
1. Higher-energy states are only possible above a certain temperature
2. Higher-energy states are only possible below a certain temperature
3. Higher-energy states become more probable as the temperature increases
4. Higher-energy states become more probable as the temperature decreases
5. None of these

On of the sets of graphs shows the **probability** that a DoF will gain an energy ΔE from its interaction with three different thermal baths: $T_A > T_B > T_C$. Which?

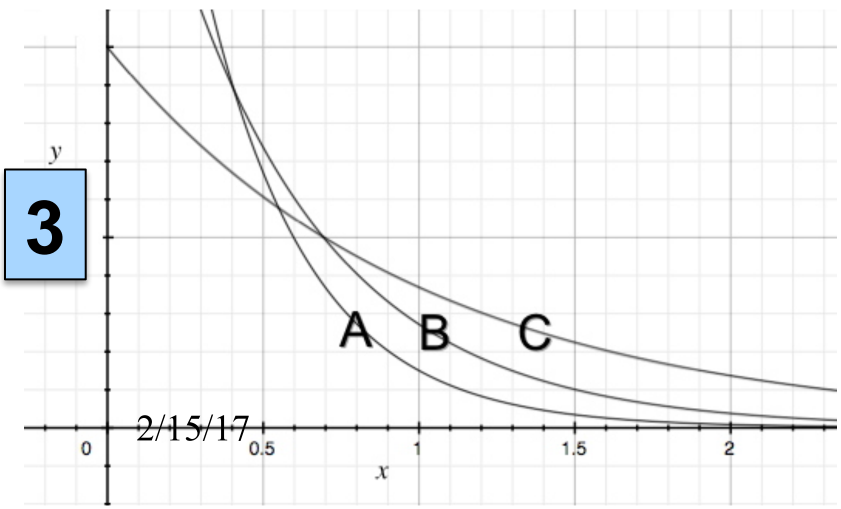
1



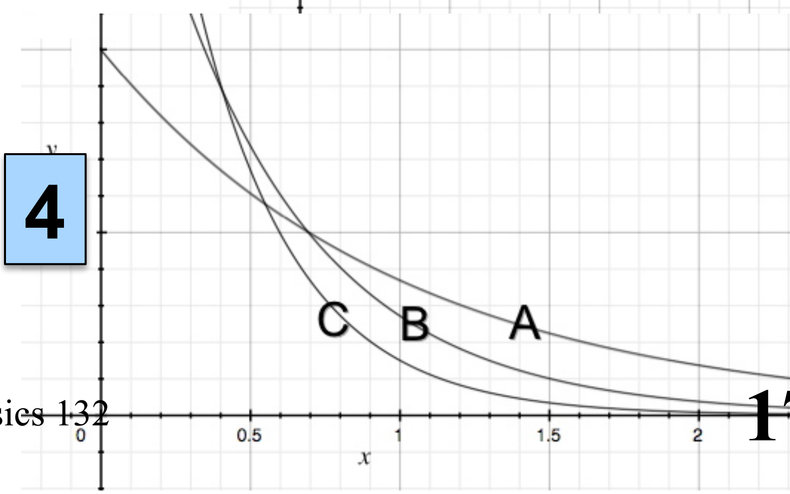
2



3



4



A gas of molecules at room temperature interacts with the potential shown below. Each molecule can be in the state E_1 or E_2. If the gas is at STP and $E_1 - E_2 = 25$ meV, then at equilibrium, the number of molecules found in the state E_1 divided by the number of molecules found in the state E_2 will be

1. About 1
2. About 1/3
3. About 3
4. Much, much larger than 1
5. Much, much smaller than 1
6. Cannot be determined from the information given.