Principles of Physics
PHY1321
PHY1331

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Final Exam
December 10, 2016

Closed book exam
Duration: 3 hrs
Return only the scantron sheets

FORCES1

1E 10 kg block rests on the flat horizontal support surface. The normal force acting on it is:

A) 9.8 N B)19.6N C) 49N D) 98N E) none of the above

KINEMATICS 1

2.E A bullet is fired through a board, 14.0 cm thick, with its line of motion perpendicular to the face of the board. If it enters with a speed of 450 m/s and emerges with a speed of 220 m/s, what is the bullet's constant acceleration as it passes through the board?

A) –500 km/s^2 B) –550 km/s^2 C) –360 km/s^2
D) –520 km/s^2 E) –275 km/s^2

FORCES 2

3.E A race car travels at constant speed 40 m/s around a banked (45° with the horizontal) circular (radius = 0.20 km) track. What is the magnitude of the resultant force on the 80-kg driver of this car?

A) 0.68 kN B) 0.64 kN C) 0.72 kN D) 0.76 kN E) 0.52 kN

FORCES 3

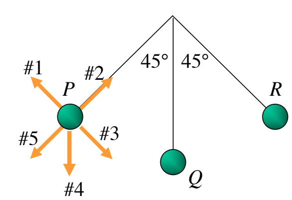
4.E A 5.0-kg object is suspended by a string from the ceiling of an elevator that is accelerating downward at a rate of 2.6 m/s^2. What is the tension in the string?

A) 49 N B) 36 N C) 62 N D) 13 N E) 52 N

FORCES 4

5E A pendulum swings back and forth, reaching a maximum angle of 45° from the vertical. Which arrow shows the direction of the pendulum bob's acceleration at *P* (the far left point of the motion)?

A. #1 (up and to the left) B. #2 (up and to the right)
C. #3 (down and to the right) D. #4 (straight down)
E. #5 (down and to the left)



LINEAR MOMENTUM 1

6E A 1.2-kg object moving with a speed of 8.0 m/s collides perpendicularly with a wall and emerges with a speed of 6.0 m/s in the opposite direction. If the object is in contact with the wall

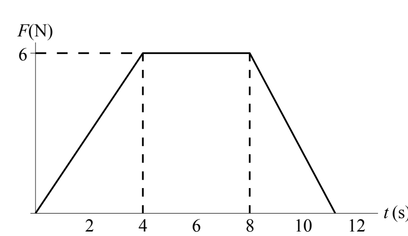
for 2.0 ms, what is the magnitude of the average force on the object by the wall?

A) 9.8 kN B) 8.4 kN C) 7.7 kN D)9.1 kN E) 1.2 kN

LINEAR MOMENTUM 2

7.E A 2.5 kg body, initially at rest, is acted on by the horizontal force shown in the graph. What is its speed in m/s when $t = 11$ s?

A) 18
B) 25
C) 27
D) 36
E) 45



8E FIRST LAW OF THERMODYNAMICS 1

Gas in a container expands at a constant pressure of 3 atm. Find the work done (in J) by the gas if the initial volume is 2 liters and the final volume is 4 liters.

A) 0 B) 150 C) 610 D) 1520 E) 1.5

9E FIRST LAW OF THERMODYNAMICS II

In a thermodynamic process, the internal energy of a system in a container, with perfect thermally insulated walls, decreases by 800 J. Which statement is correct?

A) The system lost 800 J by heat transfer to its surroundings.
B) The system gained 800 J by heat transfer from its surroundings.
C) The system performed 800 J of work on its surroundings.
D) The surroundings performed 800 J of work on the system.
E) The 800 J of work done by the system was equal to the 800 J of heat transferred to the system from its surroundings.

10E HEAT PUMP I

A heat pump has a coefficient of performance of 4. If the heat pump absorbs 20 cal of heat from the cold outdoors in each cycle, the heat expelled (in cal) to the warm indoors is

A) 34 B) 27 C) 36 D)40 E).80

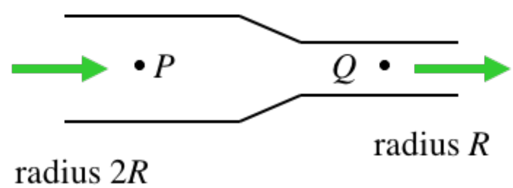
11E FIRST LAW OF THERMODYNAMICS III

Five moles of an ideal gas expands isothermally at 100°C to five times its initial volume. Find the heat flow into the system.

A) 2.5×10^4 J B) 1.1×10^4 J C) 6.7×10^3 J D) 2.9×10^3 J E) 7.0×10^2 J

12E FLUIDS I DYNAMICS

An incompressible fluid flows through a pipe of varying radius (shown in cross-section). Compared to the fluid at point *P*, the fluid at point *Q* has



A. greater pressure and greater volume flow rate.
B. greater pressure and the same volume flow rate.
C. the same pressure and greater volume flow rate.
D. lower pressure and the same volume flow rate.
E. none of the above

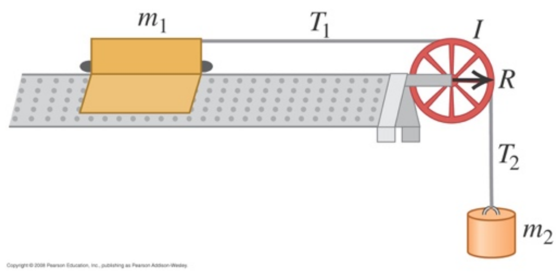
13E ROTATIONAL MECHANICS I

A spinning figure skater pulls his arms in as he rotates on the ice. As he pulls his arms in, what happens to his angular momentum *L* and kinetic energy *K*?

A. *L* and *K* both increase.
B. *L* stays the same, *K* increases.
C. *L* increases, *K* stays the same.
D. *L* and *K* both stay the same.
E. None of the above

14M ROTATIONAL MECHANICS II

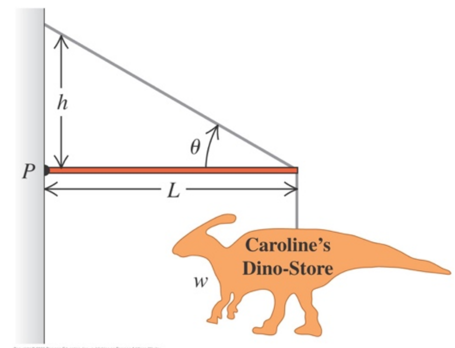
A glider of mass m_1 on a frictionless horizontal track is connected to an object of mass m_2 by a massless string. The glider accelerates to the right, the object accelerates downward, and the string rotates the pulley. What is the relationship among T_1 (the tension in the horizontal part of the string), T_2 (the tension in the vertical part of the string), and the weight m_2g of the object?



A. $m_2g = T_2 = T_1$
B. $m_2g > T_2 = T_1$
C. $m_2g > T_2 > T_1$
D. $m_2g = T_2 > T_1$
E. none of the above

15 M ROTATIONAL DYNAMICS III

A metal advertising sign (weight w) is suspended from the end of a massless rod of length *L*. The rod is supported at one end by a hinge at point *P* and at the other end by a cable at an angle *q* from the horizontal. What is the tension in the cable?



A. T = w sin θ
B. T = w cos qθ
C. T = w/(sin θ)
D. T = w/(cos θ)
E. none of the above

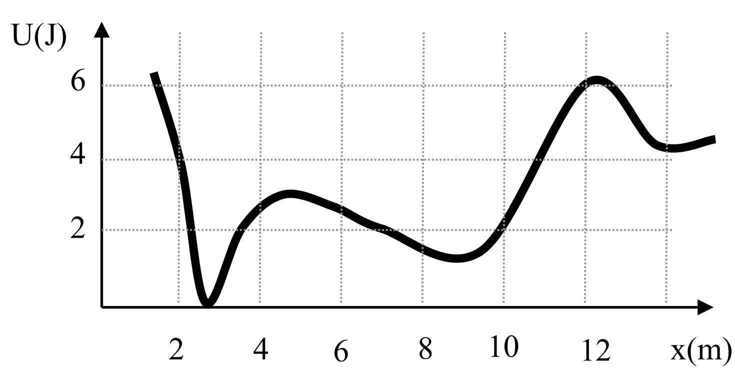
FLUIDS II DYNAMICS

16. M A hole is punched in a full milk carton, 20 cm below the top. What is the initial velocity of outflow?

A) 1.4 m/s
B) 2.0 m/s
C) 2.8 m/s
D) 3.9 m/s
E) 2.8 m/s

17M ENERGY 1

When the particle is at x= 2m it has no kinetic energy, and moves under influence of conservative force whose potential energy is shown in the diagram. What is its kinetic energy, and what is the direction of the force acting on the particle at x=10m?



A) K=0J, F is negative
B) K=2J, F is negative
C) K=3J, F is positive
D) K=4J, F is positive
E) none of the above

IDEAL GAS GAS TRANSFORMATIONS 1

18M The air in an automobile engine at 20°C is compressed from an initial pressure of 1.0 atm and a volume of 200 cm^3 to a volume of 20 cm^3. Find the temperature of the air after the compression if it behaves like an ∝∝ideal gas (γ = 1.4) and the compression is adiabatic.

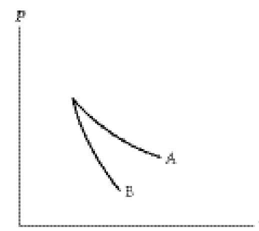
A) 73 °C B) 460°C C) 25°C D) 50°C E)20°C

CALORIMETRY 1

19M A 5-kg piece of lead (specific heat 0.03 cal/g · °C) having a temperature of 80°C is added to 500 g of water having a temperature of 20°C. What is the final equilibrium temperature (in °C) of the system?

A) 79 B) 26 C) 54 D) 34 E) 20

IDEAL GAS GAS TRANSFORMATIONS 2



20M The relation $PV = nRT$ holds for all ideal gases. The additional relation PV^γ holds for an adiabatic process. The figure below shows two curves: one is an adiabat and one is an isotherm. Each starts at the same pressure and volume. Which statement is correct? (Note: "∝" means "is proportional to".)

A) Isotherm: $P \propto \frac{1}{V}$; Adiabat: $P \propto \frac{1}{V}$: A is both an isotherm and an adiabat.

B) Isotherm: $P \propto \frac{1}{V^\gamma}$; Adiabat: $P \propto \frac{1}{V}$: B is an isotherm, A is an adiabat.

C) Isotherm: $P \propto \frac{1}{V}$; Adiabat: $P \propto \frac{1}{V^\gamma}$: A is an isotherm, B is an adiabat.

D) Isotherm: $P \propto \frac{1}{V^\gamma}$; Adiabat: $P \propto \frac{1}{V^\gamma}$: B is both an isotherm and an adiabat.

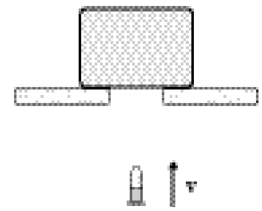
E) I cannot answer this without additional information about the starting temperature.**22.**

EQUIPARTITION THEOREM AND MAXWELL BOLTZMANN DISTRIBUTION

21M The specific heat at constant volume at 0°C of one mole of an diatomic gas is**.**

A) $\frac{1}{2}R$ **B)R** **C)** $\frac{3}{2}R$ **D)** $2R$. E) $\frac{5}{2}R$.

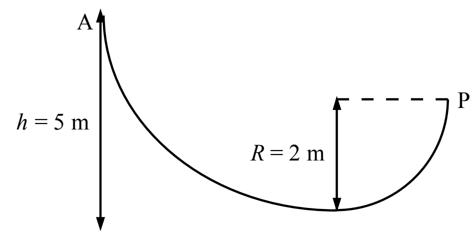
LINEAR MOMENTUM 3 **BALLISTIC PENDULUM**



22.M A 10-g bullet moving 1000 m/s strikes and embeds in the 2.0-kg block. What is the maximum height reached by the block after this collision?

A) 126 cm B) 66 cm C) 56 cm D) 51cm
E) none of the above

ENERGY II AND KINEMATICS IV

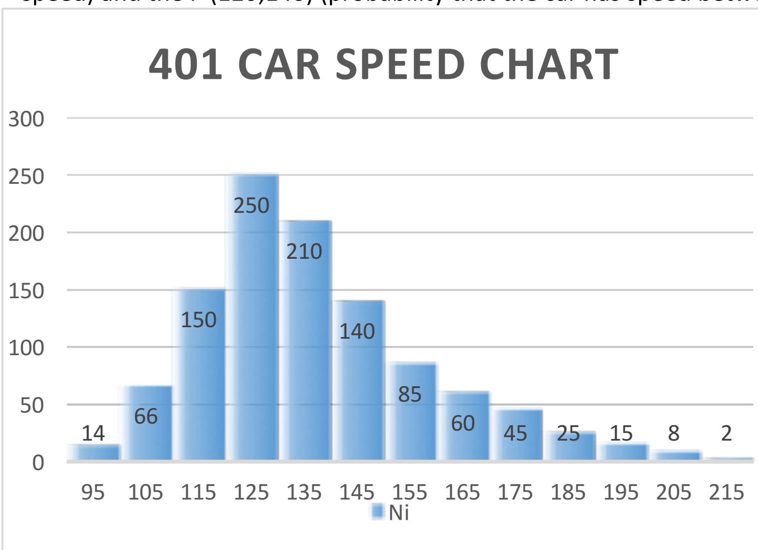


23M. A 2.0 kg block is released from A on a frictionless track. Determine the tangential and radial components of acceleration in $\mathrm{m/s^2}$ for the block at P.

a. 9.8, 15
b. 4.6, 7.5
c. 9.8, 29
d. 4.6, 15
e. 9.8, 7.5

MAXWELL SPEED DISTRIBUTION

24M The distribution of car speeds measured by a Police patrol for a particular stretch of the 401 highway between Kingston and Ottawa is shown on the figure. Each bar represents number of cars in a given interval as a function of the centre value of the interval (for example (80<v<90) is represented by 85. Which of the following about the v_{avg} (average speed), v_{rms} [root mean square speed], v_{mp} (most probable speed) and the P (120;140) (probability that the car has speed between 120km/h and 140km/h) are true:



Speed	Number of cars
951	14
105	66
115	150
125	250
135	210
145	140
155	85
165	60
175	45
185	25
195	15
205	8
215	2

A v_{mp} = 125km/h; v_{avg} =138 km/h; v_{rms} =136km/h; P(90, 120) = 0.32
B v_{mp} = 125km/h; v_{avg} =127 km/h; v_{rms} =129km/h; P(90, 120) = 0.32
C v_{mp} = 125km/h; v_{avg} =136 km/h; v_{rms} =138km/h; P(90, 120) = 0.21
D v_{mp} = 125km/h; v_{avg} =123 km/h; v_{rms} =125km/h; P(90, 120) = 0.21
E none of the above

ENTROPY I

25.M Find the change in entropy (in J/K) when 5.00 moles of an ideal monatomic gas are allowed to expand isobarically from an initial volume of 20 cm^3 to a final volume of 100 cm^3.

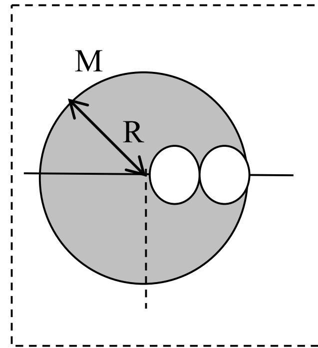
A)167 B)100 C) 67 D) 52 E) 152

KINEMATICS II

26D A race car starts from rest on a circular track. The car increases its speed at a constant rate a_t as it goes once around the track in the counterclockwise direction. Find the angle that the total acceleration of the car makes with the radius of the circle at the moment when the car completes first full circle.

A) 6.28° B) 4.55° C) 3.14° D)) 0.08° E) none of the above

ROTATIONAL MOTION IV



27D An uniform sphere of original mass M, and radius R centered at x=0 y=0, had two spheres of R/4 removed. The centers of the cavities are at x=R/4 and x= 3R/4 . What is the moment of inertia of this object as it rotates about the y axis?

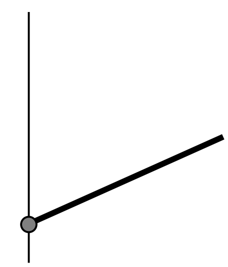
A) $\frac{2}{64}MR^2$ B)) $\frac{47}{256}MR^2$ C)) $\frac{229}{256}MR^2$
D) $\frac{997}{2560}MR^2$ E) none of these answers

ROTATIONAL DYNAMICS V

28D A uniform rod of length L=1m and mass M=1kg is pivoted freely at one end, as shown. When the rod is at angle =60^{o} with the vertical, the tangential acceleration of the rod's end is:

A 12.7m/s^2 B 6.4m/s^2
C 10.4.0 m/s^2 D 15.7m/s^2
E none of the above

Moment of inertia of a rod rotating about one end I= 1/3ML^2



ROTATIONAL DYNAMICS VI

29D A potter's wheel (a solid, uniform disk) of mass 6.1 kg and radius 0.65 m spins about its central axis at constant angular velocity of 10 rev/s. A 2.1 kg lump of clay is dropped onto the wheel at a distance 0.41 m from the axis. It sticks to the wheel and rotates with it. Find the new angular velocity of the system (IN REV/S).

A 7.85 B 8.86 C 10.0 D 11.29
E none of the above

ENTROPY II

30D. A 10-g coin, is dropped from a 325-m building. It reaches a terminal velocity of 57 m/s, and the rest of the energy is converted to heating the coin. What is the change in temperature (in K) of the coin, just before it hits the ground? (The specific heat of copper is 387 J/kg °C). What is the entropy change associated with this heating (coin initial Temperature was 300K)?

A) ΔT=9K; ΔS= 0.062J/K B) ΔT=4K; ΔS=0.051J/K C) ΔT= 5K; ΔS= 0.032J/K
D) ΔT=21K; ΔS=0.090J/K E) none of the above

LINEAR MOMENTUM III

31D The 1kg grenade is thrown vertically up with initial speed of 25m/s. It explodes in a mid-air in such a way that both of its fragments have no horizontal components of velocity after the explosion. If the maximum height reached by the 0.4 kg fragment is equal to 40m, what is the maximum height reached by the 0.6kg fragment?

A) 26.5m B) 29.9m C) 31.9m D) 32m
E) none of these answers

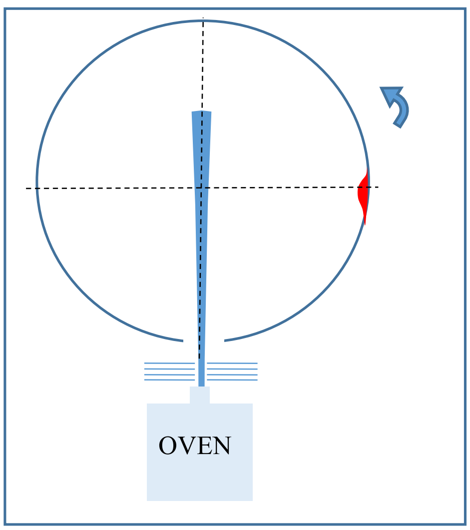
FLUID III BUYONANCY

32 D The Helium balloon of total mass = 0. 200kg and volume $1m^3$ is attached to the thin long rope of mass density of 2g/m. The coils of rope lay on the flat ground, so that as the balloon moves up the rope unwinds without any resistance. How high will the balloon rise? (take air density to be = $1.204 kg/m^3$).

A) 1204m B) 1004m C) 602m D) 502m
E) none of the above

33D Maxwell Boltzmann Distribution:

In a version of Stern- Zartman Experiment, a beam of silver atoms emerges from the nozzle and enters the rotating glass cylinder (diameter: 1m) through a single slot as shown. The atoms travel along the cylinder's diameter, while the cylinder rotates counter-clockwise at 100 rev/s.
As result the atoms are deposited on the side wall of the cylinder forming a silver layer.
After experiment is concluded the cylinder is removed from vacuum system and the thickness of the silver atoms deposit is evaluated. It turns out that the deposit is the thickest at the point exactly 90^o with respect to the main beam axis. (Main axis is defined by the beam direction). Use this information to find the temperature of the silver gas in the beam. (Molar mass of the silver is 108g.)



A) 767K
B) 985K
C) 1040K
D) 1258K
E) none of the above

Mechanics

$$v_x = \frac{dx}{dt} \qquad \vec{v} = \frac{d\vec{r}}{dt}$$

$$a_x = \frac{dv_x}{dt} \qquad \vec{a} = \frac{d\vec{v}}{dt}$$

$$\vec{r}_f = \vec{r}_o + \vec{v}_o t + \frac{1}{2}\vec{a}t^2$$

$$a_t = \frac{dv}{dt} \qquad a_c = \frac{v^2}{r}$$

$$\vec{F} = m\vec{a} \qquad \vec{F}_o = -b\vec{v}$$

$$f = \mu N \qquad R = \frac{1}{2}D\rho A v^2$$

$$F_B = \rho_l V.g$$

$$\vec{F} = -k\vec{x}$$

$$W = \int \vec{F}.d\vec{s}$$

$$k = \frac{mv^2}{2} \qquad U_g = mgh \qquad U_e = \frac{1}{2}kx^2$$

$$\vec{P} = m\vec{v} \qquad \vec{F} = \frac{d\vec{p}}{dt}$$

$$\vec{r}_{CM} = \frac{\sum m_i \vec{r}_i}{M} \qquad r_{CM} = \frac{\int r dm}{M}$$

$$V = \frac{4}{3}\pi r^3 \qquad A = 4\pi r^2 \qquad A = \pi r^2 \qquad C = 2\pi r$$

Fluid Mechanics:

$$p = p_o + \rho g h \qquad A_1 v_1 = A_2 v_2 \qquad p_o + \rho g y + \frac{1}{2}\rho v^2 = const$$

Rotational motion About a Fixed Axis

Angular speed $\omega = d\theta / dt$

Angular acceleration $\alpha = dw / dt$

Net torque $\sum \tau = I\alpha$

If $\alpha = const. \begin{cases} \omega_f = \omega_i + \alpha t \\ \theta_f = \theta_i + \omega_i t + \frac{1}{2}\alpha t^2 \\ \omega_f^2 = \omega_i^2 + 2\alpha(\theta_f - \theta_i) \end{cases}$

Work $W = \int_{\theta_i}^{\theta_f} \tau \quad d\theta$

Rotational kinetic energy $K_R = \frac{1}{2} I\omega^2$

Power $P = \tau\,\omega$

Angular momentum $L = I\omega$

Net torque $\sum \tau = dL / dt$

Circular Hoop	$I_{CM} = MR^2$
Hollow cylinder	$I_{CM} = \frac{1}{2} M(R_1^2 + R_2^2)$ where R_1: inner radius, R_2: outer radius
Solid cylinder or disc	$I_{CM} = \frac{1}{2} MR^2$
Thin Rectangle	$I_{CM} = \frac{1}{12} M(a^2 + b^2)$
Long thin rod with rotational axis through center	$I_{CM} = \frac{1}{12} ML^2$
Long thin rod with rotational axis through edge	$I_{CM} = \frac{1}{3} ML^2$
Solid sphere	$I_{CM} = \frac{2}{5} MR^2$
Thin spherical shell	$I_{CM} = \frac{2}{3} MR^2$

THERMODYNAMICS

Probability of finding the speed of a particle in the range (v;v+dv)is:

$$P(v)dv = 4\pi\left[\frac{1}{2\pi}\frac{m}{kT}\right]^{\frac{3}{2}} v^2 e^{-\frac{mv^2}{2kT}} dv$$

$$v_{MP} = \left[\frac{2kT}{m}\right]^{\frac{1}{2}} \qquad v_{rms} = \left[\frac{3kT}{m}\right]^{\frac{1}{2}} \qquad v_{avg} = \left[\frac{8kT}{\pi m}\right]^{\frac{1}{2}}$$

$$p = \frac{1}{3}\rho < v^2 > \qquad \rho = \frac{Nm}{V}$$

Integrals:

$$\int_0^{+\infty} e^{-ax^2} dx = \frac{1}{2}\sqrt{\frac{\pi}{a}} \qquad \int_0^{+\infty} x e^{-ax^2} dx = \frac{1}{2a} \qquad \int_0^{+\infty} x^2 e^{-ax^2} dx = \frac{1}{4}\sqrt{\frac{\pi}{a^3}} \qquad \int_0^{+\infty} x^3 e^{-ax^2} dx = \frac{1}{2a^2}$$

$$\int_0^{+\infty} x^4 e^{-ax^2} dx = \frac{3}{8}\sqrt{\frac{\pi}{a^5}} \qquad \int_0^{+\infty} \frac{x^3}{e^x - 1} dx = \frac{\pi^4}{15}$$

$\Delta E_{int} = Q + W$ $\qquad pV = nRT$ $\qquad \Delta S = \int \frac{dQ}{T}$

Change	ΔEint	W	Q	ΔS
P = const	$nC_v \Delta T$	$-p(V_f - V_i)$	$nC_p \Delta T$	$nC_p \ln\frac{T_f}{T_i}$
V = const	$nC_v \Delta T$	0	$nC_v \Delta T$	$nC_V \ln\frac{T_f}{T_i}$
T = const	0	$-nRT\ln\frac{V_f}{V_i}$	$nRT\ln\frac{V_f}{V_i}$	$nR\ln\frac{V_f}{V_i}$
Q = 0	$nC_v \Delta T$	$\frac{1}{\gamma - 1}\left(p_f V_f - p_i V_i\right)$	0	0

$pV^{\gamma} = const.$ $\qquad \gamma = \frac{C_P}{C_V}$ $\qquad C_p - C_v = R$

$\in_{CRN} = \frac{W}{Q} = \left|\frac{Q_H - Q_L}{Q_H}\right| = 1 - \frac{T_C}{T_H}$ $\qquad$ **COP = $\frac{\text{what we want}}{\text{what we pay for it}}$**

$\Delta L = \alpha L \Delta T$ $\qquad \Delta S = \beta S \Delta T$ $\qquad \Delta V = \gamma V \Delta T$

$P = e\,\sigma\, A\, T^4$; $\sigma = 5.67\times 10^{-8}$ W/(K^{4}m^2) $\qquad P = kA\left|\frac{dT}{dx}\right|$

$Q = mc\Delta T$ $\qquad Q = Lm$

c(water) = 4186 J/(kg C); c(ice) = 2090 J/(kg C); c(steam) = 2010J/(kg C)

L(melting) = 3.33×10^5 J/kg $\qquad$ L (vaporization) = 2.26×10^6 J/kg