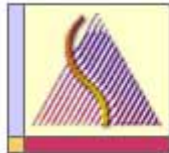




uOttawa

L'Université canadienne  
Canada's university

Principles of Physics I  
PHY1321  
PHY1331



Department of  
Physics

Instructor: Dr. Andrzej Czajkowski  
Final Exam  
December 17 2014

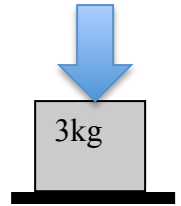
Closed book exam

10 pages  
33 questions of equal value  
15 correct answers pass the test!

Duration: 3 hrs

**RETURN ONLY THE SCANTRON SHEET!**

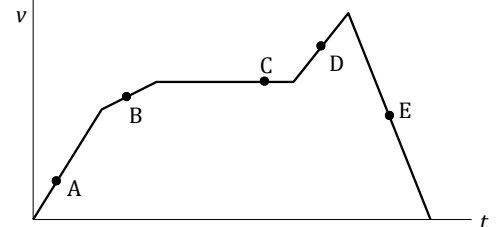
1. 3kg mass rests on the flat surface while being acted on by the vertical 10N force as. If  $g=9.9\text{m/s}^2$  the normal force acting on this body is equal to :  
A 39.7N      B 29.4N      C 3.94N      D 0N      E 2.94 N



2. Two friends pull on the rope from opposite sides. If they are not moving with respect to each other and one of them pulls with the force of 300N the tension in the rope is\_\_\_\_  
 a) 300N      b) 0N      c) 600N      d) it is impossible to answer  
 e) none of the above

3. If  $\vec{A} = 12\hat{i} - 16\hat{j}$  and  $\vec{B} = -24\hat{i} + 10\hat{j}$ , what is the direction (with respect to the X axis) of the vector  $\vec{C} = 2\vec{A} - \vec{B}$ ?  
 a)  $-49^\circ$       b)  $-41^\circ$       c)  $-90^\circ$       d)  $+49^\circ$       e)  $+221^\circ$

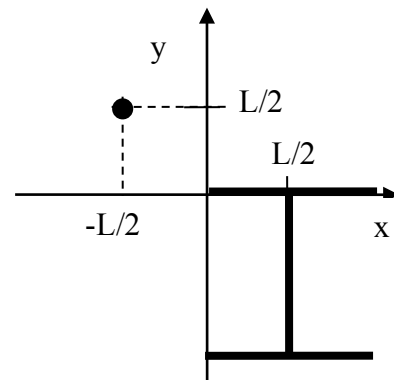
4. At which point on the velocity-time graph is the acceleration negative?  
 a. A      b. B      c. C  
 d. D      e. E



5. In the elastic collision of two or more particles the following are conserved:  
 A mass      B linear momentum      C kinetic energy  
D all of the above      E none of the above

6. Three rods of length L and mass M each, and the point-particle of mass M, are placed as shown below. The coordinates of the centre of mass of such system are:

- A  $x_{COM} = L/4$        $y_{COM} = -L/4$   
 B  $x_{COM} = -L/2$        $y_{COM} = L/2$   
 C  $x_{COM} = -L/4$        $y_{COM} = -L/2$   
 D  $x_{COM} = -L/4$        $y_{COM} = L/4$   
 E none of the above



7. A cart of mass 2kg moving at speed +5m/s collides with another stationary cart of mass 3kg on air track (no friction), and the two stick together after the collision. What is their velocity after colliding?  
A 2 m/s      B 1m/s      C -1m/s      D -2m/s      E none of the above

8. The specific heat at constant volume at 0°C of one mole of a diatomic gas is

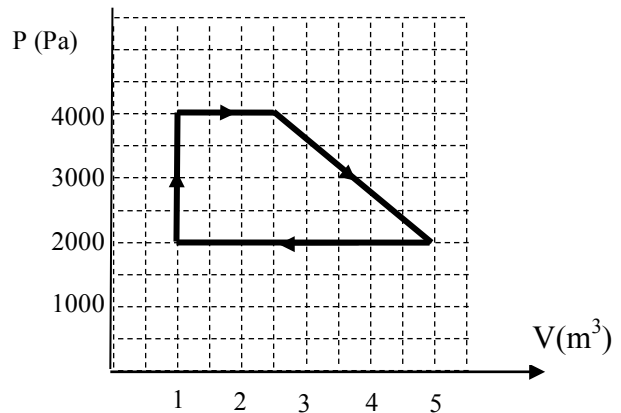
- a.  $\frac{1}{2}R$ .      b.  $R$ .      c.  $\frac{3}{2}R$ .      d.  $2R$ .      e.  $\frac{5}{2}R$ .

9. A 0.3kg particle moves from the initial position  $r_1(3i-5j-13k)m$  to  $r_2(3i-5j+7k)m$  while net force  $F(5i-7j+3k)N$  is acting on it. What is the work done by a force on the particle as it moves from initial to final position?

- A 2.9 J      B 40J      C 54J      D 60J      E 64 J

10. A reversible heat engine has a pV diagram shown on the graph. The net work performed in one cycle is approximately:

- a) 0 kJ      b) 2.0kJ  
 c) 4.2kJ      d) 5.5kJ  
 e) 10kJ



11. A steam engine absorbs 1500 J of heat and performs 500 J of mechanical work in each cycle. The efficiency of the engine is

- a. 80%      b. 60%      c. 50%      d. 33%      e. 20%

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

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

13. Some species of whales can dive to depths of 1 kilometer. What is the total pressure they experience at this depth? ( $r_{\text{sea}} = 1020 \text{ kg/m}^3$  and  $10^5 \text{ N/m}^2 = 1 \text{ ATM}$ .)

- A) 9 ATM      B) 90 ATM      C) 101 ATM      D) 111 ATM      E) 130 ATM

14. A hoop has a mass of 200g and a radius of 25cm ( $I_{\text{CM}} = MR^2$ ). It rolls without sliding along level ground at  $V_{\text{CM}} = 5\text{m/s}$ . Its total kinetic energy is:

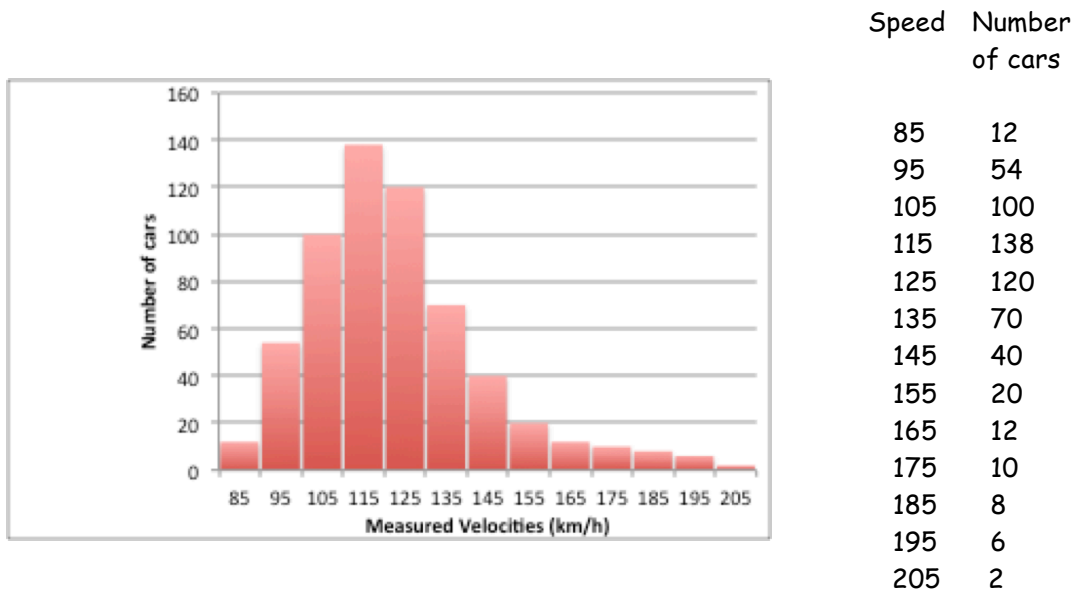
- A) 2.5 J  
B) 5 J  
 C) 10 J  
 D) 250 J  
 E) impossible to establish without extra information

- 15 Given is the two -dimensional gas made out of diatomic molecules. At sufficiently high temperatures the gas molecules are free to move around within the two dimensional plane, as well as to rotate and oscillate. Which of the following pairs correctly represents the average energy of single molecule  $E_{avg}$ ; and the  $C_v$  of the gas .

a)  $E_{avg} = \frac{1}{2}mv_x^2 + \frac{1}{2}mv_y^2$   $C_v = R$   
 b)  $E_{avg} = \frac{1}{2}mv_x^2 + \frac{1}{2}mv_y^2 + \frac{1}{2}I\omega^2$   $C_v = 3/2R$   
 c)  $E_{avg} = \frac{1}{2}mv_x^2 + \frac{1}{2}mv_y^2 + \frac{1}{2}I\omega^2$   $C_v = 2R$   
 d)  $E_{avg} = \frac{1}{2}mv_x^2 + \frac{1}{2}mv_y^2 + \frac{1}{2}I\omega^2 + \frac{1}{2}kr^2 + \frac{1}{2}mv_{osc}^2$   $C_v = 5/2R$   
 e)  $E_{avg} = \frac{1}{2}mv_x^2 + \frac{1}{2}mv_y^2 + \frac{1}{2}I_1\omega_1^2 + \frac{1}{2}I_2\omega_2^2 + \frac{1}{2}kr^2 + \frac{1}{2}mv_{osc}^2$   $C_v = 3R$

- 16 2 moles of ideal monatomic gas are kept inside sealed container at pressure of 15000Pa at temperature of 100C. What is the volume of that container?  
 a) 413m<sup>3</sup>      b) 0.413 m<sup>3</sup>      c) 0.111 m<sup>3</sup>      d) 111m<sup>3</sup>      e) none of the above

- 17 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. Which of the following conclusions 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:



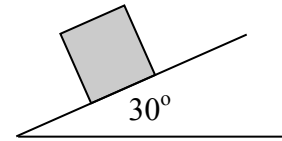
- A  $v_{mp} = 123\text{km/h}$ ;  $v_{avg} = 125\text{ km/h}$ ;  $v_{rms} = 127\text{km/h}$ ;  $P(120, 140) = 0.16$   
 B  $v_{mp} = 123\text{km/h}$ ;  $v_{avg} = 125\text{ km/h}$ ;  $v_{rms} = 127\text{km/h}$ ;  $P(120, 140) = 0.32$   
 C  $v_{mp} = 115\text{km/h}$ ;  $v_{avg} = 123\text{ km/h}$ ;  $v_{rms} = 125\text{km/h}$ ;  $P(120, 140) = 0.16$   
 D  $v_{mp} = 115\text{km/h}$ ;  $v_{avg} = 123\text{ km/h}$ ;  $v_{rms} = 125\text{km/h}$ ;  $P(120, 140) = 0.32$   
 E none of the above

- 18 The ratio of number of molecules with rms speed to the number of molecules having most probable speed in the gas of temperature  $T$  is given by:

A)  $\sqrt{\frac{3}{2}}$     B)  $\sqrt{\frac{3}{2e}}$     C)  $\frac{3}{2e}$     D)  $\frac{3}{2\sqrt{e}}$     E) none of the above

- 19 Find the force of kinetic friction acting on the 3 kg block sliding with constant velocity down the surface inclined at angle 30 degree to the horizontal.

A Impossible to answer    B 14.7N    C 29.4 N  
D 5.4N    E zero



- 20 In an adiabatic process 16 J of work are done on each mole of a gas. If the gas has 5 degrees of freedom, how much does its temperature change? Answer in terms of  $R$ .

A)  $40/R$  (K)    B)  $11.43/R$  (K)    C)  $6.4/R$  (K)    D)  $3.2/R$  (K)  
E) none of the above

- 21 An ideal gas with  $\gamma = 1.400$  expands adiabatically from a pressure of 365.0 Pa and a volume of  $70.00 \text{ m}^3$ , doing 101.0 J of work while expanding to a final volume. What is its final pressure-volume product?

A)  $139,600 \text{ Pa} \cdot \text{m}^3$     B)  $139,700 \text{ Pa} \cdot \text{m}^3$     C)  $25,710 \text{ Pa} \cdot \text{m}^3$     D)  $25,590 \text{ Pa} \cdot \text{m}^3$   
E) None of the above

- 22 Five moles of an ideal gas expands isothermally at  $100^\circ\text{C}$  to five times its initial volume. Find the heat flow into the system.

A)  $2.5 \times 10^4 \text{ J}$     B)  $1.1 \times 10^4 \text{ J}$     C)  $6.7 \times 10^3 \text{ J}$     D)  $2.9 \times 10^3 \text{ J}$     E)  $7.0 \times 10^2 \text{ J}$

- 23 A hole is punched in a full milk carton, 10 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

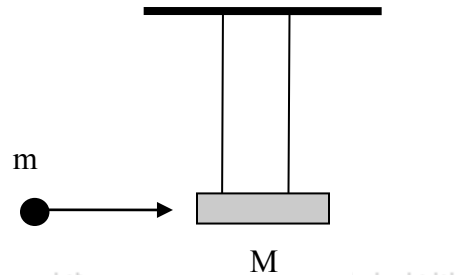
24. Find the change in entropy (in J/K) when 5.00 moles of an ideal monatomic gas are allowed to expand isobarically from an initial volume of  $20 \text{ cm}^3$  to a final volume of  $100 \text{ cm}^3$ .

a. 52  
b. 67  
c. 100  
d. 152  
e. 167

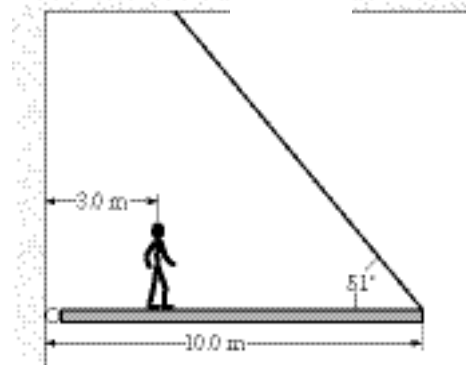
- 25 A heat pump with a coefficient of performance of 4.9 absorbs heat from the atmosphere at a rate of 30 kW. At what rate is the engine receiving work?  
A 6.1 kW    B 147 kW    C 117 kW    D 7.7 kW    E none of the above

- 26 A bubble having a diameter of 1.00 cm is released from the bottom of a swimming pool where the depth is 5.00 m. What will the diameter of the bubble be when it reaches the surface? The temperature of the water at the surface is 20.0°C, whereas it is 15.0°C at the bottom. (The density of water is  $1.00 \times 10^3 \text{ kg/m}^3$ ,  $p_{\text{atm}}=101\text{kPa}$ )  
A 1.05    B 1.15    C 1.51    D 1.65    E none of the above

- 27 A bullet of mass  $m=20\text{g}$  is fired into a block of mass  $M = 4\text{kg}$  suspended by a set of two parallel strings. The bullet embeds in the block and raises it by 4cm. The initial velocity (before the collision) of the bullet is:  
A 200m/s    B 178 m/s    C 0.89m/s  
D 89m/s    E none of the above



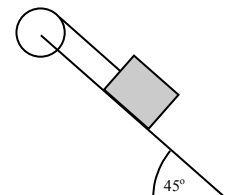
28. The figure shows a uniform, horizontal beam (length = 10 m, mass = 25 kg) that is pivoted at the wall, with its far end supported by a cable that makes an angle of  $51^\circ$  with the horizontal. If a person (mass = 60 kg) stands 3.0 m from the pivot, what is the tension in the cable?  
A. 0.83 kN    B 0.60 kN    C 0. 42 kN  
D 0.39 kN    E none of the above



**Due to rounding issue D accepted as well (the answer was 384.6)**

- 29 A block of mass =2kg can slide down a frictionless 45 degree incline but it is connected to a pulley of mass  $M =4\text{kg}$  and radius  $R=0.5\text{m}$ , as shown. The pulley can be treated as a disk ( $I_{\text{com}} = 1/2mR^2$ ). Angular acceleration of the pulley is:

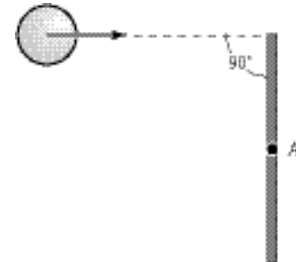
- A 6.92rad/s<sup>2</sup>    B 7.83rad/s<sup>2</sup>    C 3.46rad/s<sup>2</sup>    D 3.91 rad/s<sup>2</sup>  
E 9.02 rad/s<sup>2</sup>



When solved incorrectly (as if Tension was equal to  $mg\sin 45$ ) this will yield  $2 \times 6.92$  - but it is wrong since  $T - mg\sin 45 = ma$  (lower block has acceleration otherwise how would pulley have the angular acceleration?)

- 30 A glass window pane has an area of  $3.00 \text{ m}^2$  and a thickness of  $0.600 \text{ cm}$ . If the temperature difference between its faces is  $25.0^\circ\text{C}$ , what is the rate of energy transfer by conduction through the window. (thermal conductivity of glass:  $k_{\text{glass}}=0.8\text{W}/(\text{m C})$ )  
 a)  $5000\text{W}$     b)  $7500\text{W}$     c)  $10000\text{W}$     d)  $15000\text{W}$     e) none of the above

- 31 A thin rod of mass  $M$  and length  $L$  is struck at one end by a small ball of clay of mass  $m$ , moving with speed  $v$  as shown in the figure. The ball sticks to the rod. After the collision, the angular velocity of the clay-rod system about A, the midpoint of the rod, is



- A  $mvL$   
 B  $3mv/[2(M+3m)L]$   
 C  $(m + M/6)(vL/2)$   
 D  $mvL/2$   
 E none of the above
- 32 If  $25 \text{ kg}$  of ice at  $0^\circ\text{C}$  is combined with  $4 \text{ kg}$  of steam at  $100^\circ\text{C}$ , what will be the final equilibrium temperature (in  $^\circ\text{C}$ ) of the system.  
 A  $T=40$     B 20    C 60    D100    E none of the above

- 33 A  $20 \text{ kg}$  sample of mercury is completely solidified and liberates  $231.6 \text{ kJ}$  of energy. What is the original temperature of the mercury? (The melting point of mercury is  $234\text{K}$ , the heat of fusion of mercury is  $11.3 \text{ kJ/kg}$ , and the specific heat of mercury is  $140 \text{ J/kg}\cdot\text{K}$ ). What is the mercury entropy change  $\Delta S$  in this process?

- A  $T=240 \text{ K}$      $\Delta S=-19819\text{J/K}$   
 B  $T=236 \text{ K}$      $\Delta S=-19819\text{J/K}$   
 C  $T=2.0 \text{ K}$      $\Delta S=-19795\text{J/K}$   
 D  $T=232 \text{ K}$      $\Delta S=-19795\text{J/K}$   
 E none of the above



"Mr. O'Keefe, you'll be surprised! My basis is full!"

Mechanics

---

$$v_x = \frac{dx}{dt} \quad \vec{v} = \frac{d\vec{r}}{dt}$$
$$a_x = \frac{dv_x}{dt} \quad \vec{a} = \frac{d\vec{v}}{dt}$$
$$\vec{r}_f = \vec{r}_o + \vec{v}_o t + \frac{1}{2} \vec{a} t^2$$

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$$a_t = \frac{dv}{dt} \quad a_c = \frac{v^2}{r}$$
$$\vec{F} = m \vec{a} \quad \vec{F}_o = -b \vec{v}$$
$$f = \mu N \quad R = \frac{1}{2} D \rho A v^2$$
$$F_B = \rho_l V \cdot g$$
$$\vec{F} = -k \vec{x}$$

---

$$W = \int \vec{F} \cdot d\vec{s}$$
$$k = \frac{mv^2}{2} \quad U_g = mgh \quad U_e = \frac{1}{2} kx^2$$
$$\vec{P} = m \vec{v} \quad \vec{F} = \frac{d\vec{p}}{dt}$$
$$\vec{r}_{CM} = \frac{\sum m_i \vec{r}_i}{M} \quad r_{CM} = \frac{\int r dm}{M}$$

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

Fluid Mechanics:

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$$p = p_o + \rho gh \quad A_1 v_1 = A_2 v_2 \quad p_o + \rho gy + \frac{1}{2} \rho v^2 = \text{const}$$

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Rotational motion About a Fixed Axis

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

Angular acceleration  $\alpha = d\omega/dt$

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

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

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

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

$$I_{CM} = \frac{2}{3} MR^2$$

---

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

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

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

$$p = \frac{1}{3} \rho \langle v^2 \rangle \quad \rho = \frac{Nm}{V}$$

Integrals:

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

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

$$\Delta E_{int} = Q + W$$

$$pV = nRT$$

$$\Delta S = \int \frac{dQ}{T}$$

Change	$\Delta E_{int}$	W	Q	$\Delta S$
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	$nC_v \Delta T$	$\frac{1}{\gamma - 1} (p_f V_f - p_i V_i)$	0	0

$$pV^\gamma = const. \quad \gamma = \frac{C_p}{C_v} \quad C_p - C_v = R$$

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

$$\Delta L = \alpha L \Delta T$$

$$\Delta S = \beta S \Delta T$$

$$\Delta V = \gamma V \Delta T$$

$$P = e \sigma A T^4, \quad \sigma = 5.67 \times 10^{-8} \text{ W}/(\text{K}^4 \text{ m}^2)$$

$$P = kA \left| \frac{dT}{dx} \right|$$

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

$$c(\text{water}) = 4186 \text{ J}/(\text{kg C}); \quad c(\text{ice}) = 2090 \text{ J}/(\text{kg C}); \quad c(\text{steam}) = 2010 \text{ J}/(\text{kg C})$$

$$L(\text{melting}) = 3.33 \times 10^5 \text{ J/kg}$$

$$L(\text{vaporization}) = 2.26 \times 10^6 \text{ J/kg}$$