| Physics 101 | Hour Exam 3 | November 30, 2015 |
|---|---|---|

**Last Name:** _______________ **First Name** _______________ **ID** _______________

**Discussion Section:** ___________________ **Discussion TA Name:** ___________________

***Instructions—Turn off your cell phone and put it away.***
***Calculators cannot be shared. Please keep yours on your own desk.***

**This is a closed book exam. You have 90 minutes to complete it.**
**This is a multiple choice exam. Use the bubble sheet to record your answers.**

1. Use a #2 pencil; do **not** use a mechanical pencil or a pen. Fill in completely (until there is no white space visible) the circle for each intended input – both on the identification side of your answer sheet and on the side on which you mark your answers. If you decide to change an answer, erase vigorously; the scanner sometimes registers incompletely erased marks as intended answers; this can adversely affect your grade. Light marks or marks extending outside the circle may be read improperly by the scanner.

2. Print your last name in the **YOUR LAST NAME** boxes on your answer sheet and print the first letter of your first name in the **FIRST NAME INI** box. Mark (as described above) the corresponding circle below each of these letters.

3. Print your NetID in the **NETWORK ID** boxes, and then mark the corresponding circle below each of the letters or numerals. Note that there are different circles for the letter "I" and the numeral "1" and for the letter "O" and the numeral "0". **Do not** mark the hyphen circle at the bottom of any of these columns.

4. You may find the version of **this Exam Booklet at the top of page 2**. Mark the version circle in the **TEST FORM** box in the bottom right on the front side of your answer sheet. **DO THIS NOW!**

5. Stop **now** and double-check that you have bubbled-in all the information requested in 2 through 4 above and that your marks meet the criteria in 1 above. Check that you do not have more than one circle marked in any of the columns.

6. Print your UIN# in the **STUDENT NUMBER** designated spaces and mark the corresponding circles. You need not write in or mark the circles in the SECTION box.

7. Write in your course on the **COURSE LINE** and on the **SECTION** *line*, print your **DISCUSSION SECTION**. (You need not fill in the INSTRUCTOR line.)

8. Sign **(DO NOT PRINT)** your name on the **STUDENT SIGNATURE** *line*.

*Before starting work, check to make sure that your test booklet is complete. After these instructions, you should have **9*** ***numbered pages*** *plus 2 Formula Sheets.*

**On the test booklet:**
Write your **NAME**, your **Discussion TA's NAME**, your **DISCUSSION SECTION** and your **NETWORK-ID**. Also, write your **EXAM ROOM** and **SEAT NUMBER**.

**When you are finished, you must hand in BOTH the exam booklet AND the answer sheet. Your exam will not be graded unless both are present.**

*Academic Integrity*—**Giving assistance to or receiving assistance from another student or using unauthorized materials during a University Examination can be grounds for disciplinary action, up to and including expulsion.**

**This Exam Booklet is Version A.** Mark the **A** circle in the **TEST FORM** box in the bottom right on the front side of your answer sheet. **DO THIS NOW!**

## Exam Format & Instructions:

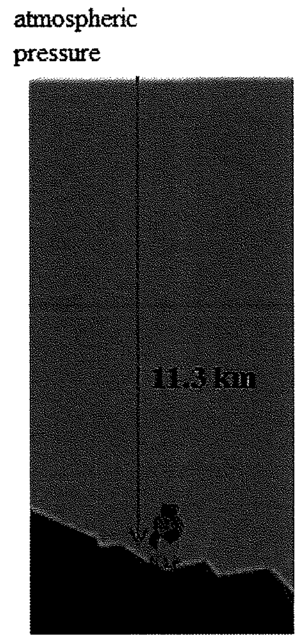
This exam is a combination of
* Three-Answer Multiple Choice (3 points each)
* Five-Answer Multiple Choice (6 points each)

There are 24 problems for a maximum possible raw score of 120 points.

**Instructions for Three-Answer Multiple Choice Problems:**
Indicate on the answer sheet the correct answer to the question (*a, b* or *c*).
Each question is worth 3 points. If you mark the wrong answer, or mark more than one answer, you receive 0 points.

**Instructions for Five-Answer Multiple Choice Problems:**
Indicate on the answer sheet the correct answer to each question (*a, b, c, d* or *e*).
Credit is awarded in the following way:
- If you mark one answer and it is correct, you will receive 6 points;
- If you mark two answers, and one of them is correct, you will receive 3 points;
- If you mark three answers and one of them is correct, you will receive 2 points.
- If you mark no answer or more than three answers, you will receive 0 points.

The bottom of the ocean in the Mariana trench in the North Pacific Ocean is 11.3 km deep. Take the density of water $\rho = 10^3$ kg/m$^3$, atmospheric pressure at sea level $P_0 = 1$ atm $= 10^5$ Pascal and $g = 9.8$ m/s$^2$.

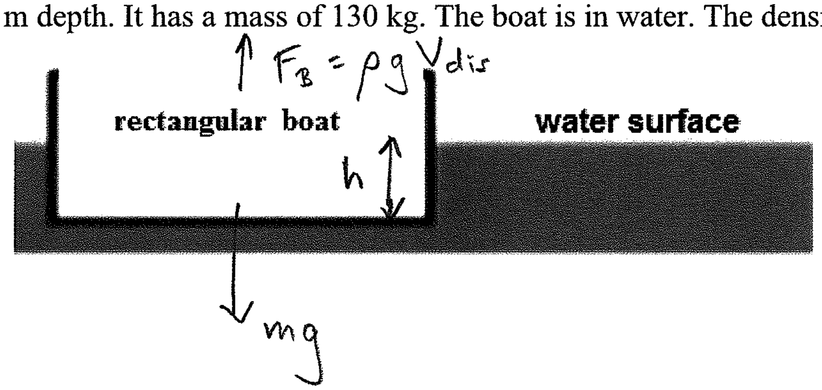



1) What is the pressure (in atmospheres) exerted on a creature living at the bottom of the ocean?

a. 2216.8
b. 1108.4
c. 1662.6
d. 1219.2
e. 886.72

$$P = P_o + \rho g d$$
$$= 1 \text{ atm} + 10^3 \text{ Kg/m}^3 \times 9.8 \text{ m/s}^2 \times 11.3 \times 10^3 \text{ m}$$
$$= 10^5 \text{ Pa} + 1.107 \times 10^8 \text{ Pa}$$
$$= 1 \text{ atm} + 1107 \text{ atm}$$

Consider a rowboat approximated as a flat-bottomed rowboat of length 3.2 m, width 1.5 m and 0.29 m depth. It has a mass of 130 kg. The boat is in water. The density of water is $\rho = 1000$ kg/m$^3$.



2) To what depth is the boat submerged?

a. 0.14 m
b. 0.02 m
c. 0.057 m
d. 0.027 m
e. 0.014 m

$$F_B = \rho \cancel{g} V_{dis} = m\cancel{g} \qquad V_{dis} = A \times h$$

$$\rho A h = m$$

$$h = \frac{m}{\rho A} = \frac{130\ \text{kg}}{1000\ \text{kg/m}^3 \times 3.2\ \text{m} \times 1.5\ \text{m}} = 0.027\ \text{m}$$

**The next two questions pertain to the situation described below.**

Water flows through a pipe which initially starts off in Region 1 with a cross-sectional area of $A_1 = 0.7\ \text{m}^2$ and then tapers to a smaller cross-sectional area $A_2$ (to be found) in Region 2. In Region 1, it flows at a speed of $v_1 = 0.13$ m/s and in Region 2, it flows at $v_2 = 2.6$ m/s. The pressure in Region 1 is $P1 = 8 \times 10^3$ Pa. (1 Pa = 1 N/m$^2$). Water is incompressible so its density stays constant at $\rho_{H_2O} = 1000\ \text{kg/m}^3$.

3) The cross-sectional area of Region 2, $A_2$, is

a. 0.1 m$^2$
b. 0.035 m$^2$
c. 0.07 m$^2$
d. 14 m$^2$
e. 28 m$^2$

$$A_1 V_1 = A_2 V_2 \Rightarrow A_2 = A_1 \frac{V_1}{V_2}$$

$$= 0.7\ \text{m}^2 \times \frac{0.13}{2.6}$$

$$= 0.035\ \text{m}^2$$

4) Assuming that the two regions are at the same height, the pressure in Region 2, $P_2$, is

a. 1.3 x 10$^3$ Pa
b. 15 x 10$^3$ Pa
c. 2.3 x 10$^3$ Pa
d. 4.6 x 10$^3$ Pa
e. 11 x 10$^3$ Pa

$$P_1 + \frac{1}{2}\rho v_1^2 + \cancel{\rho g y_1} = P_2 + \frac{1}{2}\rho v_2^2 + \cancel{\rho g y_2} \qquad y_1 = y_2$$

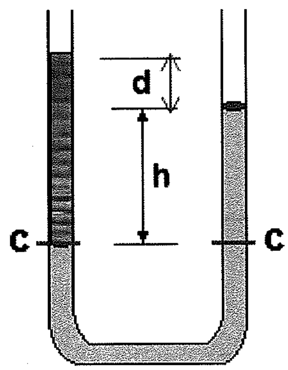
$$P_2 = P_1 + \frac{1}{2}\rho (v_1^2 - v_2^2)$$

$$= 8 \times 10^3\ \text{Pa} + \frac{1}{2} 10^3\ \text{kg/m}^3 \left[(0.13)^2 - (2.6)^2\right] \text{m}^2/\text{s}^2$$

$$= 4.63 \times 10^3\ \text{Pa}$$

**The next three questions pertain to the situation described below.**

Consider the U-tube shown below. The uniformly shaded section is filled with water. The striped section (left) is filled with a liquid that does not mix with water. Given h = 10 cm, d = 3 cm, and take the density of water $\rho_w = 1.0\ g/cm^3$.




5) At level C, compared to the pressure on the left side, the pressure on the right side is

a. same    Pascal's principle
b. smaller
c. larger

6) When comparing the densities of the liquid and water, one can say the density of the liquid is

a. same
b. larger
c. smaller    See below

7) Determine the density of liquid $\rho_l$

a. 2.6 $g/cm^3$
b. 0.77 $g/cm^3$
c. 1 $g/cm^3$
d. 0.38 $g/cm^3$
e. 1.3 $g/cm^3$

Weight of liquid = Weight of water above C

$\rho_L \cancel{g} (h+d) = \rho_w \cancel{g} h$

$\rho_L = \rho_w \dfrac{h}{h+d} = 1\ g/cm^3 \times \dfrac{10}{10+3}$

$= 0.77\ g/cm^3$

**The next three questions pertain to the situation described below.**

A pendulum consists of a bob of mass 0.3 kg suspended by a massless string of length 7 m from a ceiling. It performs small oscillations about its equilibrium position.

8) What is the angular frequency of oscillation, ω?

$$\omega = \sqrt{g/L} = \sqrt{\frac{9.8\ m/s^2}{7\ m}} = 1.2\ rad/s$$

a. 3.6 rad/s
b. 4.7 rad/s
c. 1.2 rad/s
d. 2.6 rad/s
e. 0.57 rad/s

9) If the length of the pendulum string is increased by a factor of 4, the angular frequency changes by a factor of

a. 1/2
b. 1/4
c. 4
d. 2
e. No change

10) On the surface of Jupiter, the acceleration due to gravity is about 2.5 times that on the surface of Earth (the gravitational pull on Jupiter is much stronger). Compared to Earth, when the pendulum is taken to Jupiter, assuming that the string length stays fixed, its angular frequency

a. stays the same.
b. increases (faster oscillations).
c. decreases (slower oscillations).

**The next three questions pertain to the situation described below.**

A mass of m = 0.5 kg attached to a massless spring is displaced from its equilibrium position by a distance A and is then released to perform simple harmonic oscillations. The spring constant of the spring is k = 8 N/m.

11) What is the time period of oscillations, T?

$$T = \frac{2\pi}{\omega} = 2\pi\sqrt{\frac{m}{K}} = 2\pi\sqrt{\frac{0.5\ kg}{8\ N/m}} = 1.57\ s$$

a. 1.6 s
b. 0.79 s
c. 4 s
d. 25 s
e. 0.25 s

12) If the total energy of the oscillating mass is 0.4 J, what is its maximum displacement, A?

$$U' = \frac{1}{2} K A^2 = 0.4\ J$$

$$A = \sqrt{\frac{2U'}{K}} = \sqrt{\frac{2 \times 0.4\ J}{8\ N/m}} = 0.32\ m$$

a. 0.15 m
b. 0.96 m
c. 0.7 m
d. 0.32 m
e. 1.2 m

13) What is the maximum speed of the mass, $v_{max}$?

$$U = \frac{1}{2} m v^2$$

$$v = \sqrt{\frac{2U}{m}} = \sqrt{\frac{2 \times 0.4\ J}{0.5\ kg}} = 1.26\ m/s$$

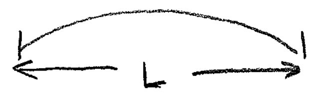
a. 1.3 m/s
b. 2.9 m/s
c. 0.62 m/s
d. 3.9 m/s
e. 5.1 m/s

**The next four questions pertain to the situation described below.**

An E guitar string of length 40 cm is fixed at both ends. It vibrates at the fundamental frequency of f = 330 Hz.

14) What is the velocity of a wave travelling in the string?

$v = \lambda f$ $\lambda = 2L$




a. 520 m/s
b. 130 m/s
c. 260 m/s

$= 2Lf$

$= 2 \times 0.4\,m \times 330/s = 264\ m/s$

15) If the amplitude of the fundamental is doubled, what is the new frequency of vibration of the wave, f'?

a. f' = 4f
b. f' = f/4
c. f' = f
d. f' = 2f
e. f' = f/2

16) The string is retuned. The new tension is F" = 4F. What is the new frequency of vibration of the string, f"?

$v = \sqrt{\frac{F}{\mu}} = \lambda f$

a. f" = f
b. f" = 4f
c. f" = f/2
d. f" = f/4
e. f" = 2f

Increase $F \rightarrow 4F \Rightarrow f \rightarrow 2f$

17) The original string is replaced by a string having the same length (40 cm) and tension F, but has four times the mass, M"' = 4M. What is the new frequency of vibration of the string, f"'?

$v = \sqrt{\frac{F}{\mu}} = \lambda f$

a. f"' = 2f
b. f"' = f/4
c. f"' = f/2
d. f"' = f
e. f"' = 4f

Increase $\mu \rightarrow 4\mu \Rightarrow f \rightarrow \frac{1}{2} f$

18) Which of the following is NOT associated with sound?

a. Beats
b. Interference
c. Doppler effect
d. Oscillations of electric fields
e. Periodic changes in pressure

19) Sound is a

a. longitudinal wave
b. diffusion wave.
c. transverse wave.

20) A wave of wavelength 20 cm is propagated through the following media. In which medium will the wave move the fastest?

a. The wave velocity depends upon the frequency of the wave.
b. The wave velocity depends upon the amplitude of the wave.
c. A loose, light rope.
d. A tight, heavy rope.
e. A tight, light rope. ← $v = \sqrt{\frac{F}{\mu}}$

21) A longitudinal wave moves through the air. The net movement of the air molecules is

↑ Note

a. in the direction of propagation of the wave.
b. zero
c. in the direction perpendicular to the propagation of the wave

22) Trumpet players riding on a train flatcar are travelling at a high speed towards another group of stationary trumpet players standing near the track. If all players are told to play an "A" note on their trumpets, what will a stationary observer standing between the two groups hear?

a. A beat frequency.
b. A steadily increasing pitch as the train moves closer.
c. No note as a result of destructive interference.

23) A sound source and an observer are both in motion. Which of the following will result in the greatest increase in observed frequency?

a. The source and observer are both moving toward each other.
b. The source is moving toward the observer, but the observer is moving away from the source.
c. The source and observer are both moving away from each other~~longitudinal wave.~~

24) A car speeds down the highway. Its stereo is on blasting music very loudly. An observer is standing by the roadside. As the car approaches he notices that a musical note that should be G (f = 392 Hz) sounds like A (440 Hz). Take the speed of sound to be 343 m/s. Assume the observer has a perfect pitch. How fast is the car moving?

a. 37.4 m/s
b. 42 m/s
c. 84 m/s
d. 21 m/s
e. 74.8 m/s

$$f_{obrerver} = f_{source} \times \frac{V_{wave}}{V_{wave} - V_{source}} \qquad (V_{obrerver} = 0)$$

$$f_{obrerver} \times (V_{wave} - V_{source}) = f_{source} \times V_{wave}$$

$$-f_{obrevver} V_{source} = (f_{source} - f_{obrerver}) V_{wave}$$

$$V_{source} = -\frac{(f_{source} - f_{obrerver})}{f_{obrerver}} V_{wave}$$

$$= -\frac{(392 - 440)}{440} \times 343 \text{ m/s}$$

$$= 37.4 \text{ m/s}$$

# Physics 101 Formulas

**Kinematics**

$\mathbf{v}_{ave} = \Delta\mathbf{x}/\Delta t$ $\quad$ $\mathbf{a}_{ave} = \Delta\mathbf{v}/\Delta t$

$v = v_0 + at$ $\quad$ $x = x_0 + v_0 t + {}^1/_2 at^2$ $\quad$ $v^2 = v_0^2 + 2a\Delta x$

$g = 9.8\ m/s^2 = 32.2\ ft/s^2$ (near Earth's surface)

**Dynamics**

$\Sigma\mathbf{F} = m\mathbf{a}$ $\quad$ $F_g = Gm_1m_2 / R^2$ $\quad$ $F_g = mg$ (near Earth's surface)

$f_{s,max} = \mu_s F_N$ $\quad$ Gravitational constant, $G = 6.7 \times 10^{-11}\ N \cdot m^2/kg^2$

$f_k = \mu_k F_N$ $\quad$ $a_c = v^2 / R = \omega^2 R$

**Work & Energy**

$W_F = FD\cos(\theta)$ $\quad$ $K = {}^1/_2 mv^2 = p^2/2m$ $\quad$ $W_{NET} = \Delta K = K_f - K_i$ $\quad$ $E = K + U$

$W_{nc} = \Delta E = E_f - E_i = (K_f + U_f) - (K_i + U_i)$

$U_{grav} = mgy$

**Impulse & Momentum**

Impulse $\mathbf{I} = \mathbf{F}_{ave}\Delta t = \Delta\mathbf{p}$

$\mathbf{F}_{ave}\Delta t = \Delta\mathbf{p} = m\mathbf{v}_f - m\mathbf{v}_i$

$\mathbf{F}_{ave} = \Delta\mathbf{p}/\Delta t$

$\Sigma\mathbf{F}_{ext}\Delta t = \Delta\mathbf{P}_{total} = \mathbf{P}_{total,final} - \mathbf{P}_{total,initial}$ $\quad$ (momentum conserved if $\Sigma\mathbf{F}_{ext} = 0$)

$\mathbf{x}_{cm} = (m_1\mathbf{x}_1 + m_2\mathbf{x}_2)/(m_1 + m_2)$

**Rotational Kinematics**

$\omega = \omega_0 + \alpha t$ $\quad$ $\theta = \theta_0 + \omega_0 t + {}^1/_2 \alpha t^2$ $\quad$ $\omega^2 = \omega_0^2 + 2\alpha\Delta\theta$

$\Delta x_T = R\Delta\theta$ $\quad$ $v_T = R\omega$ $\quad$ $a_T = R\alpha$

(rolling without slipping: $\Delta x = R\Delta\theta$ $\quad$ $v = R\omega$ $\quad$ $a = R\alpha$)

1 revolution = $2\pi$ radians

**Rotational Statics & Dynamics**

$\tau = Fr \sin\theta$

$\Sigma\tau = 0$ and $\Sigma F = 0$ (static equilibrium)

$\Sigma\tau = I\alpha$

$W = \tau\theta$ (work done by a torque)

$\mathbf{L} = I\boldsymbol{\omega}$ $\quad$ $\Sigma\boldsymbol{\tau}_{ext}\Delta t = \Delta\mathbf{L}$

(angular momentum conserved if $\Delta\boldsymbol{\tau}_{ext} = 0$)

$K_{rot} = {}^1/_2 I\omega^2 = L^2/2I$ $\quad$ $K_{total} = K_{trans} + K_{rot} = {}^1/_2 mv^2 + {}^1/_2 I\omega^2$

**Moments of Inertia (I)**

$I = \Sigma mr^2$ (for a collection of point particles)

$I = {}^1/_2 MR^2$ (solid disk or cylinder)

$I = {}^2/_5 MR^2$ (solid ball)

$I = {}^2/_3 MR^2$ (hollow sphere)

$I = MR^2$ (hoop or hollow cylinder)

$I = {}^1/_{12} ML^2$ (uniform rod about center)

**Fluids**

$P = F/A$, $\quad$ $P(d) = P(0) + \rho gd$ change in pressure with depth d

$\rho = M/V$ (density)

Buoyant force $F_B = \rho g V_{dis}$ = weight of displaced fluid

Flow rate $Q = v_1A_1 = v_2A_2$ $\quad$ continuity equation $\quad$ (area of circle $A = \pi r^2$)

$P_1 + {}^1/_2 \rho v_1^2 + \rho g y_1 = P_2 + {}^1/_2 \rho v_2^2 + \rho g y_2$ $\quad$ Bernoulli equation

$\rho_{water} = 1000\ kg/m^3$

$1 m^3 = 1000$ liters

$1\ atm = 1.01 \times 10^5\ Pa$

$1\ Pa = 1\ N/m^2$

**Simple Harmonic Motion**

Hooke's Law: $F_s = -kx$

$U_{spring} = {}^1/_2 kx^2$

$x(t) = A\cos(\omega t)$ or $x(t) = A\sin(\omega t)$

$v(t) = -A\omega\sin(\omega t)$ or $v(t) = A\omega\cos(\omega t)$

$a(t) = -A\omega^2\cos(\omega t)$ or $a(t) = -A\omega^2\sin(\omega t)$

$\omega^2 = k/m$ $T = 2\pi/\omega = 2\pi\sqrt{m/k}$ $f = 1/T$

$x_{max} = A$ $v_{max} = \omega A$ $a_{max} = \omega^2 A$ $\omega = 2\pi f$

For a simple pendulum $\omega^2 = g/L$, $T = 2\pi\sqrt{L/g}$

**Harmonic Waves**

$v = \lambda / T = \lambda f$

$v^2 = F/(m/L)$ for wave on a string

$v = c = 3 \times 10^8$ m/s for electromagnetic waves (light, microwaves, etc.)

$I = P/(4\pi r^2)$ (sound intensity)

**Sound Waves**

Loudness: $\beta = 10 \log_{10}(I/I_0)$ (in dB), where $I_0 = 10^{-12}$ W/m$^2$

$$f_{observer} = f_{source}\frac{v_{wave} - v_{observer}}{v_{wave} - v_{source}}$$ (Doppler effect)

**Temperature and Heat**

Temperature: Celsius ($T_C$) to Fahrenheit ($T_F$) conversion: $T_C = (5/9)(T_F - 32)$

Celsius ($T_C$) to Kelvin ($T_K$) conversion: $T_K = T_C + 273$

$\Delta L = \alpha L_0 \Delta T$ $\Delta V = \beta V_0 \Delta T$ thermal expansion

$Q = cM\Delta T$ specific heat capacity

$Q = L_f M$ latent heat of fusion (solid to liquid) $Q = L_v M$ latent heat of vaporization

$Q = \kappa A \Delta T t/L$ conduction

$Q = e\sigma T^4 A t$ radiation ($\sigma = 5.67\times10^{-8}$ J/(s·m$^2$·K$^4$))

$P_{net} = e\sigma A(T^4 - T_0^4)$ (surface area of a sphere $A = 4\pi r^2$)

**Ideal Gas & Kinetic Theory**

$N_A = 6.022 \times 10^{23}$ molecules/mole Mass of carbon-12 = 12.000 u

$PV = nRT = Nk_BT$ $R = 8.31$ J/(mol·K) $k_B = R/N_A = 1.38 \times 10^{-23}$ J/K

$KE_{ave} = {}^3/_2 k_BT = {}^1/_2 m v_{rms}^2$ $U = {}^3/_2 Nk_BT$ (internal energy of a monatomic ideal gas)

$v_{rms}^2 = 3k_BT/m = 3RT/M$ (M = molar mass = kg/mole)

**Thermodynamics**

$\Delta U = Q + W$ (1'st law)

$U = ({}^3/_2)nRT$ (internal energy of a monatomic ideal gas for fixed n)

$C_V = ({}^3/_2)R = 12.5$ J/(mol·K) (specific heat at constant volume for a monatomic ideal gas)

$Q_H + Q_C + W = 0$ (heat engine or refrigerator)

$e = -W/Q_H = 1 + Q_C/Q_H$ $e_{max} = 1 - T_C/T_H$ (Carnot engine)

$-Q_C/Q_H = T_C/T_H$ at maximum efficiency (2'nd law)

$W = -P\Delta V$ (work done by expanding gas)

$\Delta S = Q/T$ (entropy)