Tear off sheet

Physics 135aL   Final Examination   December 13, 2001
Thurs. 8:00 – 10:00 am

Instructor______________________

Name
(printed)____
Last,   First   Initial

This is a closed book exam. No notes or other materials are allowed. However *calculators* are permitted. Express you results to 3 significant figures. Your signature represents that you understand these rules and that you agree neither to give nor receive help during this exam,

Name (Signed)____

Social Security No. ______________________________________

Physics 135aL Final Exam Fall 2001

Ogawa Thurs. Dec. 13, 2001
Barsony 8:00-10:00 am

Instructor ____________________________

Name (Printed) ____

Last, First Initial

Name (Signed) ____

Social Security No. ____

1.________________15 pts.

2.________________20 pts.

3.________________20 pts.

4.________________25 pts.

5.________________20 pts.

6.________________20 pts

7.________________20 pts

Total_____________140 pts

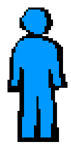
This is a closed book exam. No notes or other materials are allowed. However *calculators* are permitted. Express you results to 3 significant figures.

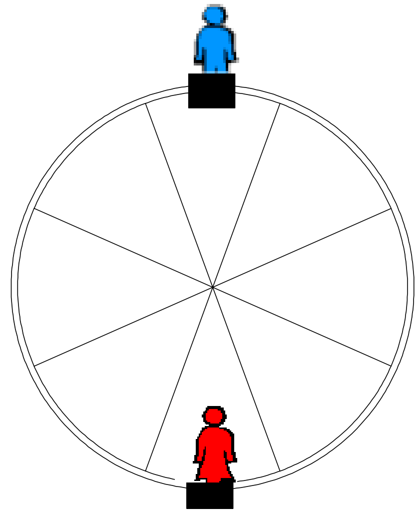
1. (15 pts) You are on the roof of the physics building 46.0 m above the ground. Your physics professor, who is 1.8 m tall, is walking on the ground towards the building at a constant speed of 1.2 m/s. If you wish to drop an egg on your professor's head, where should the professor be when you release the egg? Take the origin (0.00 m, 0.00 m) of the x-y coordinate system to be on the ground and at the base of the building where you are dropping the egg (i.e. the professor is walking towards the origin).

Ans. __________

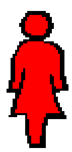
2. (20pts) In a Ferris wheel ride, two passengers of the same mass m = 60.0 kg moves in a vertical circle of radius R = 8.00 m with a constant rotational rate of 1 revolution per 10.0 seconds. Assume that the seat remains upright during the motion. Take the positive y-axis to be in the upward direction.

2.1 (5pts) Draw the free-body diagram of the *male passenger* at the *top* of the Ferris wheel and write down Newton's 2nd Law applied to him.





2.2 (5 pts) Draw the free-body diagram of the *female passenger* at the *bottom* of the Ferris wheel and write down Newton's 2nd Law applied to her.



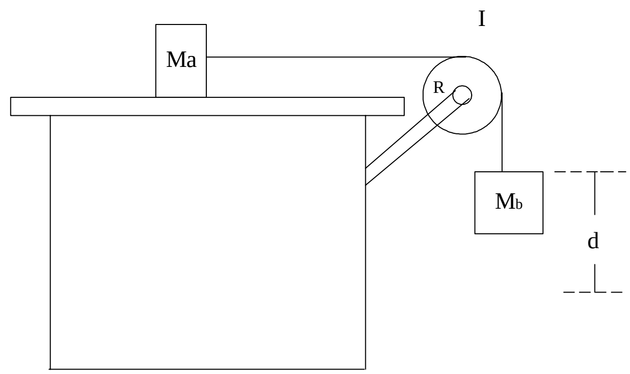
2.3 (5pts) find the force that the seat exerts on the *male passenger* at the top of the circle.

Ans.__________

2.4 (5pts) find the force that the seat exerts on the *female passenger* at the bottom of the circle.

Ans.___________

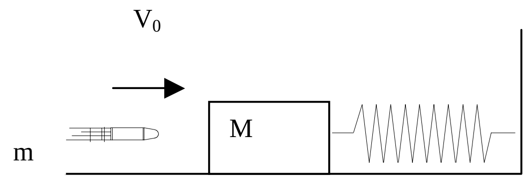
3. (20pts) The pulley in the Figure has radius R = 3 cm and moment of Inertia I = 2.25×10^{-4} kg m^2 about its axis of rotation. The cord that connects the masses (M_a= 2kg and M_b= 3 kg) goes over the pulley and does not slip over the pulley. If coefficient of friction between M_a and the tabletop is μ_k = 0.15 and if the system starts from rest, use *energy* methods to determine the speed of the masses when M_b has descended a distance d = 1.5 m its original position.



Ans. ______________

4. (25pts) A lead bullet of mass m = 0.0100kg and specific heat capacitance c = 130 J/kgCº strikes and embeds itself in a wooden block of mass M = 0.99 kg which rests on a horizontal frictionless surface and is attached to a coil spring. The impact compresses the spring 10.0 cm. Calibration of the spring shows that a force of 1.00 N is required to compress the spring 1.00 cm.

4.1 (2pts) What is the spring constant in N/m?



Ans.___________

4.2 (4pts) What is the period of oscillation of the *block and bullet* after impact?

Ans.___________

4.3 (2pts) What is the maximum potential energy of the spring?

Ans.____________

4.4 (4pts) What is the maximum velocity, V, of the *block and bullet* after impact?

Ans._____________

4.5 (4pts) What is the initial velocity v_0, of the *bullet* before entering the block?

Ans.__________

4.6 (5pts) How much heat, Q, is produced after the impact?

Ans.___________

4.7 (4pts) If *all* the heat found in problem 4.6 is used to raise the temperature of the *bullet*, what is the temperature of the bullet just after impact? The bullet was 30ºC just before entering the block. Assume the specific heat of the wood is much larger than that of the bullet so we can neglect the heat that is initially absorbed by the wood. If you are unable to solve (4.6) use $Q = Q_{err} = 45$ J.

Ans.___________

5. (20 pts) The sound level of a loud speaker at a rock concert 20 m away is 100 dB at a frequency 1kHz. Assume that the speaker spreads its energy uniformly in 3-dimensions.

5.1 (5pts) What is the Intensity at 20 m?

Ans.________

5.2 (5pts7) What is the total acoustic output power of the speaker?

Ans. ________

5.3 (5pts) At what distance is the intensity equal to $1 W/m^2$ (the threshold of pain)?

Ans.________

5.4 (5pts) If the audience races towards the speaker at 10 m/s (they want pain), what frequency would the 1kHz pitch be heard by them? The speed of sound is v = 350 m/s in the concert hall.

Ans. ____________

6. (20pts)

6.1 (6pts) A steel I-beam of cross sectional area 0.031 m^2 is rigidly connected between two vertical steel girders (modulus of elasticity is 2×10^{11} N/m^2 and the coefficient of linear expansion of steel is $\alpha = 12 \times 10^{-6}$ /C°). If the beam is installed when the temperature was 30 ºC, what stress is developed in the I-beam when the temperature is -30 ºC? Is it under tension or compression?

Stress = ______________

Tension or Compression ___________

6.2 (6pts) A string of length 1.5 m and linear mass density 4.30×10^{-4} kg/m is under a tension of 5N. What is the wavelength and frequency of the first overtone standing wave? (The first overtone is the natural frequency just above the fundamental mode).

wavelength _______________

frequency ________________

6.3 (8pts) Homework problem: What mass of steam at 100 ºC must be added to 1kg of ice to yield liquid water at 20 ºC? The specific heat of water is c_W = 1cal/gmCº, the latent heat of fusion = 80 cal/gm, and the latent heat of vaporization is 540 cal/gm Cº.

Ans.____________

7. (20 pts) The density of seawater is $\rho = 1.025 \times 10^3$ kg/m^3. A balloon filled with air at the surface of the ocean has a volume of 1.5 m^3 at 20º C. What is the volume of the balloon 100 m below the surface where the temperature is - 20º C? (hint: recall the child's helium-filled balloon problem rising in the atmosphere.)

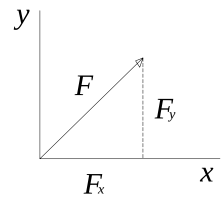
Ans. ___________

Formula Sheet 1.

Statistics

$$\bar{x} = \frac{\sum_i x_i}{N} \qquad \sigma = \sqrt{\sum_i \frac{(\bar{x} - x_i)^2}{N-1}}$$

Vectors



$$F_x = F\cos\theta$$

$$F_y = F\sin\theta$$

$$F = \sqrt{F_x^2 + F_y^2} \qquad \mathrm{Tan}\,\theta = \frac{F_y}{F_x}$$

Kinematics

$$\mathrm{v} = \mathrm{v}_o + a\,t \qquad \omega = \omega_0 + \alpha\,\mathrm{t} \qquad \omega = 2\pi\, f$$

$$\mathrm{v}^2 - \mathrm{v}_0^2 = 2a\,(x - x_0) \qquad \omega^2 - \omega_0^2 = 2a\,(\theta - \theta_0) \qquad f = \frac{1}{T}$$

$$x = x_0 + \mathrm{v}_0\, t + \tfrac{1}{2} a\, t^2 \qquad \theta = \theta_0 + \omega_0\, t + \tfrac{1}{2}\alpha\, t^2 \qquad \mathrm{v} = \omega\,\mathrm{r}$$

Static's **friction**

$$a_T = \alpha\,\mathrm{r}$$

$$\sum F_x = 0 \qquad f_s = \mu_s\,\mathrm{N} \qquad a_c = \frac{\mathrm{v}^2}{\mathrm{r}}$$

$$\sum F_y = 0 \qquad f_k = \mu_k\,\mathrm{N}$$

$$\sum \vec{\tau}_A = 0$$

Mechanics

$$\vec{F} = \frac{\Delta\vec{P}}{\Delta t} = m\,\vec{a} \qquad \vec{P} = m\vec{\mathrm{v}} \qquad \vec{P}_T = \sum_i m_i\,\vec{\mathrm{v}}_i$$

$$\vec{\tau} = \vec{\mathrm{r}} \times \vec{F} = \mathrm{r}F\sin\theta \qquad \tau = \mathrm{I}\alpha \qquad \mathrm{L} = \mathrm{I}\omega$$

$$\mathrm{KE}_{\mathrm{Trans}} = \tfrac{1}{2} m\mathrm{v}^2 \qquad \mathrm{KE}_{\mathrm{Rot}} = \tfrac{1}{2}\mathrm{I}\omega^2$$

$$\mathrm{PE}_{\mathrm{g}} = mgh \qquad \mathrm{PE}_{\mathrm{s}} = \tfrac{1}{2}\mathrm{k}\, x^2$$

$$\mathrm{Work} = \mathrm{W} = \vec{F} \bullet \Delta\vec{x} = F\Delta x\cos\theta$$

Constants & Conversions

$$g = 9.80\ \mathrm{m/s}$$

$$\mathrm{R} = 8.315\ \mathrm{J/K}$$

$$\mathrm{k} = 1.38 \times 10^{-23}\ \mathrm{J/K}$$

$$1\,\mathrm{cal} = 4.186\ \mathrm{J}$$

$$1\,\mathrm{atm} = 101.3\,\mathrm{kPa} = 760\ \mathrm{mm\text{-}Hg}$$

Conservation of Energy

$$\mathrm{W}_{\mathrm{nc}} = \Delta\mathrm{KE} + \Delta\mathrm{PE}$$

$$\mathrm{Q}_{\mathrm{lost}} = \mathrm{Q}_{\mathrm{gained}}$$

Conservation of Momentum

$$\vec{P}_{\mathrm{i}} = \vec{P}_{\mathrm{f}} \qquad \mathrm{L}_{\mathrm{i}} = \mathrm{L}_f$$

$$\mathrm{e} = \frac{\mathrm{v}_1' - \mathrm{v}_2'}{\mathrm{v}_2 - \mathrm{v}_1} \qquad x_{\mathrm{cm}} = \frac{\sum_i m_i x_i}{\sum_i m_i}$$

Formula Sheet 2.

Geometry

Area of a circle: πr^2

Volume of a sphere: $\frac{4}{3}\pi r^3$

Area of sphere: $4\pi r^2$

Fluids

density $\rho = \frac{\text{mass}}{\text{volume}}$

Flow rate $= Q = Av = \text{Constant}$ **(Continuity eq.)**

$\text{Pressure} = P = \frac{F}{A}$

$P + \frac{1}{2}\rho v^2 + \rho g h = \text{Constant}$

$$Q = \frac{\pi r^4 (P_H - P_L)}{8\eta L}$$

Elastic Properties

$\frac{\text{Sress}}{\text{Strain}} = Y; G; B$

$\text{Stress} = F_\perp / A$; $F_\parallel /A$; P

$\text{Strain} = \Delta L/L_0$; $\text{Tan}\phi$; $\Delta V/V_0$

Oscillations / Resonance

$\omega = \sqrt{\frac{k}{m}}$ $\omega = \sqrt{\frac{g}{\ell}}$

$F = -kx$ $PE_s = \frac{1}{2}kx^2$ $E_T = \frac{1}{2}mv^2 + \frac{1}{2}kx^2$

$E_T = \frac{1}{2}mv^2_{max} = \frac{1}{2}kx^2_{max}$

$v = \sqrt{\frac{T}{\mu}}$ $\mu = \frac{m}{L}$ $\Delta L_{node} = \frac{\lambda}{2}$ $v = \lambda f$

Thermal Properties

$\Delta L = L_0 \alpha \Delta T$

$\Delta Q = mc\Delta T$

$Q_f = m\ell_f$ $Q_v = m\ell_v$

$\frac{\Delta Q}{\Delta T} = kA\frac{\Delta T}{L}$ $I = e\sigma T^4$

$PV = nRT = \frac{N}{N_A}RT = NkT$

Sound

$I = \text{Power}/\text{Area}$

$\beta = 10 \text{ Log}\frac{I}{I_0}$

$I_0 = 10^{-12}$ W/m^2

$f = f_0(1 + \frac{v_{obs}}{v})$ approach

$f = \frac{f_0}{(1 - \frac{v_s}{v})}$ approach

Where v = sound speed