PHYS 101 Final Examination - B

Tuesday, 8 August, 2006 Name _____

Time: 3 hours Student number _____

No aids such as calculators, formula sheets are permitted.

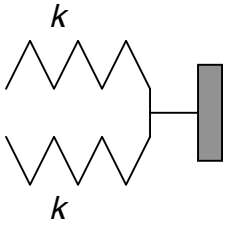
Explain your reasoning with words and diagrams for problems 4 to 9.

Area of sphere = $4\pi R^2$ Volume of sphere = $4\pi R^3/3$ $k_B = 1.38\text{x}10^{-23}$ J/K^o

1. For each of the following five questions, circle only one answer. (10 marks)

(i) A moving box receives an impulse directed to the north. As a result, the box
- (a) accelerates towards the north.
- (b) is north of the equator.
- (c) stops.
- (d) has a velocity pointing south.
- (e) has a velocity pointing north.

(ii) Two identical springs, each with force constant k, are attached in parallel. What is the effective force constant of the springs, taken together?



(a) $k/2$ (b) $4k$ (c) k (d) $k/4$ (e) $2k$

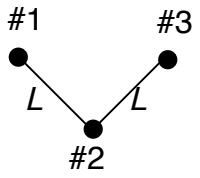
(iii) A 10 kg block is at rest on a level surface, where the coefficient of static friction is 0.5 and that for kinetic friction is 0.3. A horizontal force of 35 N is applied to the block. What is the frictional force on the object (take $g = 10$ m/s^2)?
(a) 100 N (b) 30 N (c) 50 N (d) 35 N (e) 0 N

(iv) An arrow shot vertically into the air rises to a height h before it falls back to Earth. If the speed of the arrow as it leaves the bow is doubled, how high could the arrow rise?
(a) $8h$ (b) h (c) $16h$ (d) $2h$ (e) $4h$

(v) The weight of an object on the Moon is 1/6 the weight of the same object on the Earth. If an object moves with a speed v and kinetic energy K on the Earth, what is the kinetic energy of the same object moving with speed v on the Moon?
(a) $6K$ (b) K (c) $36K$ (d) $K/6$ (e) $K/36$

2. For each of the following five questions, circle only one answer. (10 marks)

(i) Consider three objects (1, 2, 3) arranged at right angles, with distances as shown. What is the moment of inertia of this configuration with respect to an axis passing through object #2 and perpendicular to the 1-2-3 plane. Each mass is equal to M and is concentrated at a point.



(a) $2ML^2$ (b) $3ML^2$ (c) ML^2 (d) $ML^2/2$ (e) none of [a-d]

(ii) A hollow ring of mass m and radius R rolls without slipping along a table at speed v. What is its kinetic energy?

(a) $mv^2/4$ (b) $mv^2/2$ (c) mv^2 (d) $3mv^2/2$ (e) $2mv^2$

(iii) A wave travels with a speed v_o along a string under tension. If the mass of the string is doubled, but its length and tension are unchanged, what would be the speed of the wave?

(a) $v_o/\sqrt{2}$ (b) $\sqrt{2}\, v_o$ (c) $2v_o$ (d) $v_o/2$ (e) $v_o/4$

(iv) The siren on an ambulance emits sound at a wavelength λ, according to its driver. When the ambulance drives around a traffic circle, an observer at the centre of the circle measures the wavelength of the sound from the siren to be

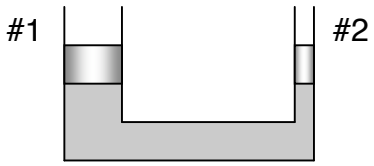
(a) λ (b) $<\lambda$ (c) $>\lambda$ (d) 0 (e) depends on the ambulance speed

(v) Two radio stations, CBX and CBY, broadcast at the same power; however, the broadcast frequency of CBX is one-half of CBY. What is the ratio of the amplitudes A of their signal? A_{CBX} / A_{CBY} is given by

(a) 1/2 (b) 2 (c) 1 (d) 1/4 (e) 4

3. For each of the following five questions, circle only one answer. (**15 marks**)

(i) Pistons #1 and #2 in a hydraulic press have radii $2R$ and R, respectively. If the fluid in the press is incompressible, what force does piston #2 receive if piston #1 receives F?



(a) $F/4$ (b) $F/2$ (c) $4F$
(d) $16F$ (e) $2F$

(ii) In an ideal gas, what is the ratio of the mean speed of an unbound oxygen atom compared to an oxygen molecule?

(a) 2 (b) $\sqrt{2}$ (c) 1 (d) 1/2 (e) $1/\sqrt{2}$

(iii) Water is deliver to a single house on a very large lot through a pipe of radius R. A developer tears down the house and replaces it with a cluster of 16 townhouses. What must be the radius of the main water pipe to service the new homes so that they each have the same flow rate as the original house?

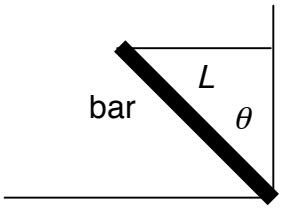
(a) $16R$ (b) R (c) $4R$ (d) $8R$ (e) $2R$

(iv) Air flowing horizontally with a speed v over the flat roof of a building reduces the pressure on the roof by an amount P_v. What is the pressure reduction if the speed of the air is $2v$?
(a) 0 (b) $4P_v$ (c) $2P_v$ (d) $P_v/2$ (e) $P_v/4$

(v) Two balls of the same radius but densities $\rho_1 = 2\rho_L$ and $\rho_2 = 3\rho_L$ are placed in a liquid of density ρ_L. What is the ratio of the effective weight w_1 / w_2 of the balls?
(a) 2/3 (b) 3/2 (c) 3/4 (d) 4/3 (e) none of [a-d]

4. An object of mass mass m is attached to one end of a massless string of length L. The top end of the string is attached to the ceiling. Keeping the string straight, the object is drawn to the side and released from rest at an angle θ_o with respect to the vertical. As a function of the angle θ (with respect to the vertical), what is the tension in the string? (15 marks)

5. A bar of mass M and length L is held against a wall by a horizontal wire, as shown. The bottom of the bar is held wedged against the base of the wall, making an angle θ with respect to the wall. What is the magnitude of the force exerted on the bar at the corner? (9 marks)



6. A singing bird delivers about 1.25×10^{-3} watts of power.
(a) If the power is uniformly distributed in all directions, what is the sound intensity level (in dB) at a distance of 10 m?
(b) What is the magnitude of the intensity level if a small flock of 10 birds sings at once? (8 marks)

7. A passenger jet plane with a pressurized cabin (atmospheric pressure of 1.00×10^5 Pa) is travelling at 720 km/hr.
(a) If the air outside the plane has a density of just 0.2 kg/m^3 and one-tenth atmospheric pressure), what is the pressure difference across a window on the side of the plane?
(b) If the window is a 20 cm by 30 cm rectangle, what force does it experience?
(c) For a given air speed, how does the pressure difference change with altitude?
(15 marks)

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8. The smog that rises over Vancouver every day originates from emission gases and dust. Let's model a dust particle as a cube 10 μm to the side composed of material with a density of 2.5×10^3 kg/m^3.
(a) What is the mean speed of a dust particle at $T = 20$ °C?
(b) To what height h above the ground could a dust particle travel at room temperature before its thermal energy is lost to gravity? Assume $g = 10$ m/s^2 = constant.
(10 marks)

9. A thin, square plate is made from a material with a coefficient of linear expansion α. Obtain an approximate expression for the coefficient of area expansion (define it as γ) for this plate in terms of α. (8 marks)

Answers
1. a, e, d, e, b.
2. a, c, a, a, b.
3. a, b, e, b, e.
4. $T = mg\,(3\cos\theta - 2\cos\theta_o)$.
5. $R = mg\{1 + (\tan\theta / 2)^2\}^{1/2}$.
6. (a) 60 dB; (b) 70 dB.
7. (a) 94,000 Pa; (b) 5640 N; (c) discuss the effect of a smaller air density ρ (with increasing altitude) on the external statis pressure and on the contribution $\rho v^2/2$.
8. (a) 6.9×10^{-5} m/s; (b) 2.4×10^{-10} m.
9. $\gamma = 2\alpha$.