First sample final exam (**not in the same format** as the 2008 Final Exam)

Part I Multiple Choice Circle the correct answer (4 points each).

1. A **Carnot** engine whose high temperature (T_H) source is at 127$^{\mathrm{O}}$C takes in 200 calories and expels 160 calories to the low temperature (T_C) sink. What is the value of the low temperature T_C (answer in $^{\mathrm{O}}$C)

a) 102 b) 87 c) 40 d) 0 e) none of these

2. One kilogram of water at 0$^{\mathrm{O}}$C is heated to 100$^{\mathrm{O}}$C, but NOT turned into steam. What is the change in entropy (specific heat of water is 1 cal/(gram-C$^{\mathrm{O}}$); answer in calories/Kelvin)?

a) 312 b) 20 c) 10 d) 0 e) none of these

3. A coal burning TVA electric power plant produces 800 MW (mega-Watts) of power and has an efficiency of 30%. It loses its waste heat by means of large cooling towers which evaporate water (L_V = 2256 kJ/kg). Assuming all of the waste heat goes into evaporating the water, how much water is evaporated in one second (answer in kg)?

a) 827 b) 2,667 c) 677 d) 2.82 e) none of these

4. What fraction of an iceberg's volume is submerged ($\rho_{\mathrm{seawater}} = 1025$ kg/m^3 and $\rho_{\mathrm{ice}} = 917$ kg/m^3)?

a) 95% b) 93% c) 91% d) 89% e) none of these

5. Two stars of masses M and $6M$ are separated by a distance D. How from from star M should a third mass be placed in order that it have no net gravitational force acting on it?

a) $0.41D$ b) $0.33D$ c) $0.37D$ d) $0.29D$ e) none of these

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6. Two vectors have magnitudes 10 and 11, and their scalar product is -100. What is the magnitude of the vector sum of these two vectors?

a) 6.6 b) 4.6 c) 8.3 d) 9.8 e) none of these

7. A rock is thrown downward from an unknown height h with an initial speed of 10 m/s. It strikes the ground 3.0 seconds later. What is the value of h (answer in meters)?

a) 44 b) 14 c) 74 d) 30 e) none of these

8. A person whose weight is 800 N is riding in an elevator which is accelerating downward at the rate of 1.5 m/s^2. What is the magnitude of the force of the elevator floor on the person (answer in N)?

a) 680 b) 800 c) 920 d) 120 e) none of these

9. A 50 kg child is riding in a Ferris wheel which has a radius of 10 m and travels in a vertical circle. The Ferris wheel completes one revolution every 10 seconds. What is the magnitude of the force on the child exerted by the seat in which the child is sitting when the Ferris wheel is at the top if its motion (answer in N, ignore any forces exerted by a seatbelt or a restraining bar)?

a) 290 b) 490 c) 690 d) 200 e) none of these

10. A person lifted a 2.0 kg object from the bottom of a well at a constant speed of 2.0 m/s for 5.0 s. How much work was done (answer in Joules)?

a) 220 b) 200 c) 240 d) 270 e) none of these

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11. A 1.2 kg mass is projected from ground level at some unknown angle with speed of 30 m/s. The mass is seen to just clear a 16 m high fence before falling back to the ground. What was the kinetic energy of the mass when it cleared the fence (ignore air friction and use conservation of energy, answer in J)?

a) 352 b) 188 c) 0.0 d) insufficient information provided e) none of these

12. A 2.0 kg ball moving with a velocity of $3\,\hat{\mathbf{i}} - 4\,\hat{\mathbf{j}}$ bounces off the floor such that its new velocity is $3\,\hat{\mathbf{i}} + 4\,\hat{\mathbf{j}}$. What is the impulse exerted on the ball by the floor ($\hat{\mathbf{j}}$ is in the vertical direction, answer in Newton-seconds)?

a) $+16\,\hat{\mathbf{j}}$ b) $-16\,\hat{\mathbf{j}}$ c) $+12\,\hat{\mathbf{i}}$ d) $-12\,\hat{\mathbf{i}}$ e) none of these

13. A horizontal disk with a 10 cm radius rotates about a vertical axis through its center. The disk starts from rest at $t = 0$ seconds and has a constant angular acceleration of 2.1 rad/s^2. At what time t will the centripetal (a_c or a_r) and the tangential (a_t) components of the total acceleration be equal in magnitude (answer in seconds)?

a) 0.55 b) 0.63 c) 0.69 d) 0.59 e) none of these

14. A merry-go-round has a radius $R = 2$ m and a moment of inertia $I = 250$ kg-m^2. It is rotating about its center at 10 revolutions per minute. A child of mass 25 kg hops onto edge of the merry-go-round. What is the new rotational speed of the merry-go-round with the child at the outer edge (answer in revolutions per minute)?

a) 10 b) 9 c) 8 d) 7 e) none of these

15. A particle has its oscillatory motion described by $x(t) = 10\sin(\pi t + \pi/3)$ where x is in meters and t is in seconds. At what time are the potential and kinetic energies equal (answer in seconds)?

a) 0.7 b) 0.8 c) 0.9 d) 0.6 e) none of these

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Part II Worked Problems Solve each of the problems. *Show clearly all your work and which equations you use.* Partial credit will be given. All numerical answers must have units attached where appropriate. (15 points each. Spend no more than 10 minutes/problem.)

1. A 225 kg mass is suspended from a strut which makes a 45^{o} angle with the horizontal. In turn, the strut is clamped to the floor with a hinge and also supported by a light cable at 30^{o} to the horizontal which has a tension T and is attached to a vertical wall. The strut is 3.0 m long and has a mass of 45.0 kg.

a) Draw a free-body diagram showing all the forces acting on the strut.

b) Write down *three* independent equations indicating that the strut is in rotational and translational equilibrium.

c) Solve for the tension T

d) Solve for the horizontal and the vertical components of the force R which is begin exerted by the hinge on the strut.

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2. An ideal *diatomic* gas is caused to pass through three branches making a closed cycle as described. From point 1 to point 2 there is an isothermal expansion. From point 2 to point 3 there is an isochoric drop in pressure, and from point 3 back to point 1 there is an adiabatic compression. The volume at points 2 and 3 is triple the volume V_1 at the original point 1, and you may take the pressure at point 1 to be P_1 and the temperature at point 1 to be T_1.

a) In terms of the original point 1 values P_1, T_1, and V_1, what are the values of P_2 and T_2 for point 2.

b) In terms of the original point 1 values P_1, T_1, and V_1, what are the values of P_3 and T_3 for point 3.

c) What is the ΔQ and the ΔE_{int} for each of the three branches of the closed cycle?

d) What is the net work done in the closed cycle, where again your answer is in terms of P_1, T_1, and V_1?

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3. A 5.00 kg block is pulled along a horizontal frictionless table The pulling force F is 12.0 N acting at 25^{o} above the horizontal.

a) What is the acceleration of the block?

b) Suppose the force F is increased slowly, but still acts at 25^{o} above the horizontal. What is the maximum value of the magnitude of F consistent with the block remaining on the table?

c) What is the acceleration of the block for the force F given in part b) ?

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4. A mass of 1.30 kg is placed at the end of a light rod 0.780 m long having negligible mass. This system rotates in a horizontal circle about the other end of the rod at 5010 revolutions/minute.

a) What is the moment of inertia of this system about the axis of rotation?

b) Air resistance exerts a force of 0.023 Newtons on the mass, opposite to the direction of motion at all times. How much torque must be applied to the system in order to keep it rotating at constant angular velocity?

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5. The density of steel is 7800 kg/m^3, and the maximum stress that can be placed on steel cable is 7.0 x 10^8 N/m^2. What is the fastest speed of a transverse wave in a steel cable? (Note your answer should not depend on the diameter or thickness of the cable.)

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6 There is a horizontal, thick aluminum cylinder 85.0 cm long. A steel wire, also 85.0 cm long, is attached to the aluminum cylinder by means of fasteners on each end of the cylinder. The whole system is initially at $10.0^{\rm O}$ C and then it is heated to $120^{\rm O}$ C.

a) What is the length expansion of the big aluminum cylinder (the coefficient of linear expansion for aluminum is 23 x $10^{-6}/{\rm C}^{\rm O}$)?

b) What *would have been* the length expansion of the steel wire (the coefficient of linear expansion for steel is 11 x $10^{-6}/{\rm C}^{\rm O}$)?

c) Because it is attached to the aluminum cylinder, the steel wire actually stretches the same length as did the aluminum in part a), so there is a tension force in the steel because of the extra stretching. What is the size of that tension force assuming that the steel wire had a diameter of 0.1 cm originally (The *Elastic* or *Young's* Modulus for steel is $E = 10^9$ N/m^2)?