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Nagy,

Tibor

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Keep this exam **CLOSED** until advised by the instructor.

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120 minute long closed book exam.

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Fill out the bubble sheet: last name, first initial, **student number (PID)**. Leave the section, code, form and signature areas empty.

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Four two-sided handwritten 8.5 by 11 help sheets are allowed.

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When done, hand in your **test** and your **bubble sheet**.

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Thank you and good luck!

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Possibly useful constants:

- $g = 9.81 \text{ m/s}^2$
- $G = 6.67 \times 10^{-11} \text{ Nm}^2/\text{kg}^2$
- $\rho_{\text{water}} = 1 \text{ kg/l} = 1000 \text{ kg/m}^3$
- $1 \text{ atm} = 101.3 \text{ kPa} = 101,300 \text{ Pa}$
- $N_A = 6.02 \times 10^{23} \text{ 1/mol}$
- $R = 8.31 \text{ J/molK}$
- $k_B = 1.38 \times 10^{-23} \text{ J/K}$
- $c_{\text{water}} = 4.1868 \text{ kJ/kg}^\circ\text{C} = 1 \text{ kcal/kg}^\circ\text{C}$
- $1 \text{ cal} = 4.1868 \text{ J}$
- $\sigma = 5.67 \times 10^{-8} \text{ W/m}^2\text{K}^4$
- $b = 2.90 \times 10^{-3} \text{ m K}$

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Possibly useful Moments of Inertia:

- Solid homogeneous cylinder:  $I_{\text{CM}} = (1/2)MR^2$
  - Solid homogeneous sphere:  $I_{\text{CM}} = (2/5)MR^2$
  - Thin spherical shell:  $I_{\text{CM}} = (2/3)MR^2$
  - Straight thin rod with axis through center:  $I_{\text{CM}} = (1/12)ML^2$
  - Straight thin rod with axis through end:  $I = (1/3)ML^2$
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Please, sit in row:

Thank you!

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*1 pt* Are you sitting in the row assigned?

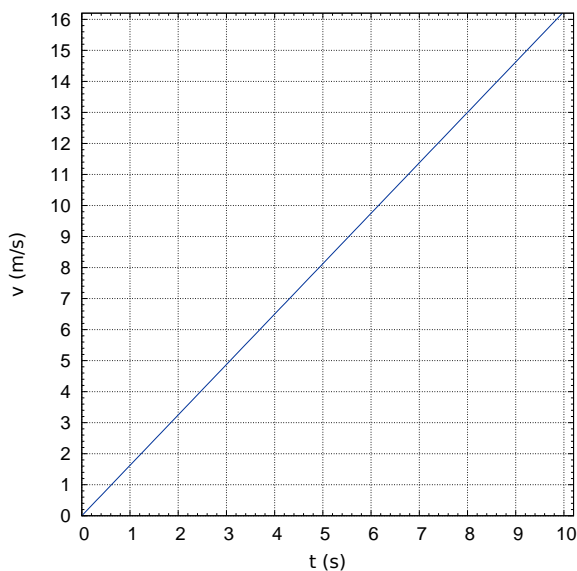
1.A  Yes, I am.

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**2 pt** An apple, a brick and a hammer are all dropped from the second floor of a building. Which object(s) will hit the ground first?

2. **A**  The apple will hit first.  
**B**  The brick will hit first.  
**C**  The hammer will hit first.  
**D**  The apple and the brick will hit the ground first in a tie.  
**E**  The brick and the hammer will hit the ground first in a tie.  
**F**  The hammer and the apple will hit the ground first in a tie.  
**G**  They all hit the ground at the same time.  
**H**  Without knowing the masses of the objects, we cannot tell which one hits the ground first.

The graph shows the speed of a car as a function of time.



**2 pt** Initially the car is at rest. What is the acceleration of the car? Please, note that the graph goes through at least one grid intersection point.

(in  $\text{m/s}^2$ )

3. **A**  0.7729    **B**  1.121    **C**  1.625  
**D**  2.356    **E**  3.417    **F**  4.954  
**G**  7.183    **H**  10.42

**2 pt** How much distance does the car cover between  $t_1 = 2.15$  s and  $t_2 = 5.55$  s?

(in m)

4. **A**  4.461    **B**  5.576    **C**  6.970    **D**  8.713  
**E**  10.89    **F**  13.61    **G**  17.02    **H**  21.27

**4 pt** A baseball is projected horizontally with an initial speed of 8.95 m/s from a height of 1.87 m. What is the speed of the baseball when it hits the ground? (Neglect air friction.)

(in  $\text{m/s}$ )

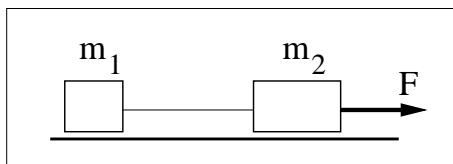
5. **A**  4.21    **B**  4.93    **C**  5.77  
**D**  6.75    **E**  7.89    **F**  9.24  
**G**   $1.08 \times 10^1$     **H**   $1.26 \times 10^1$

**4 pt** Two forces  $\mathbf{F}_1 = -7.70\mathbf{i} + 3.30\mathbf{j}$  and  $\mathbf{F}_2 = 6.60\mathbf{i} + 4.60\mathbf{j}$  are acting on a mass of  $m = 6.00$  kg. The forces are measured in newtons. What is the magnitude of the object's acceleration?

(in  $\text{m/s}^2$ )

6. **A**   $7.09 \times 10^{-1}$     **B**   $8.30 \times 10^{-1}$     **C**   $9.71 \times 10^{-1}$   
**D**  1.14    **E**  1.33    **F**  1.56  
**G**  1.82    **H**  2.13

Two masses,  $m_1 = 2.45$  kg and  $m_2 = 8.08$  kg are on a horizontal frictionless surface and they are connected together with a rope as shown in the figure.



**3 pt** The rope will snap if the tension in it exceeds 60.0 N. What is the maximum value of the force  $F$  which can be applied?

(in N)

7. A   $1.10 \times 10^2$     B   $1.46 \times 10^2$     C   $1.94 \times 10^2$   
 D   $2.58 \times 10^2$     E   $3.43 \times 10^2$     F   $4.56 \times 10^2$   
 G   $6.07 \times 10^2$     H   $8.07 \times 10^2$

**3 pt** What is the acceleration of the whole system, when this maximum force is applied?

(in  $\text{m/s}^2$ )

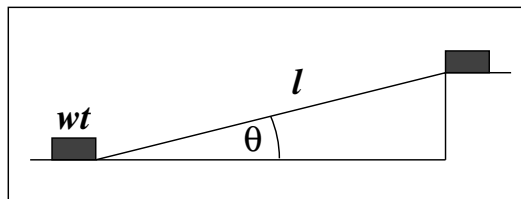
8. A   $1.69 \times 10^1$     B   $2.45 \times 10^1$     C   $3.55 \times 10^1$   
 D   $5.15 \times 10^1$     E   $7.47 \times 10^1$     F   $1.08 \times 10^2$   
 G   $1.57 \times 10^2$     H   $2.28 \times 10^2$

**4 pt** An athlete, swimming at a constant speed, covers a distance of 135 m in a time period of 2.05 minutes. The drag force exerted by the water on the swimmer is 56.0 N. Calculate the power the swimmer must provide in overcoming that force.

(in W)

9. A   $4.62 \times 10^1$     B   $6.15 \times 10^1$     C   $8.17 \times 10^1$   
 D   $1.09 \times 10^2$     E   $1.45 \times 10^2$     F   $1.92 \times 10^2$   
 G   $2.56 \times 10^2$     H   $3.40 \times 10^2$

A block with a weight of 694 N is pulled up at a constant speed on a very smooth ramp by a constant force. The angle of the ramp with respect to the horizontal is  $\theta = 27.0^\circ$  and the length of the ramp is  $l = 13.7$  m.

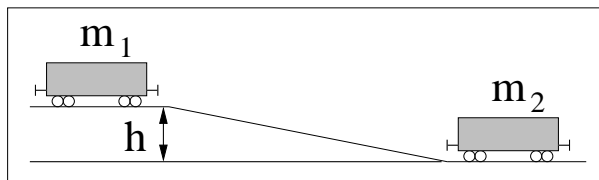


**4 pt** Calculate the work done by the force in pulling the block all the way to the top of the ramp. (Neglect friction.)

(in J)

10. A   $3.38 \times 10^3$     B   $3.82 \times 10^3$     C   $4.32 \times 10^3$   
 D   $4.88 \times 10^3$     E   $5.51 \times 10^3$     F   $6.23 \times 10^3$   
 G   $7.04 \times 10^3$     H   $7.95 \times 10^3$

**4 pt** A railroad cart with a mass of  $m_1 = 12.6$  t is at rest at the top of an  $h = 13.8$  m high hump yard hill.

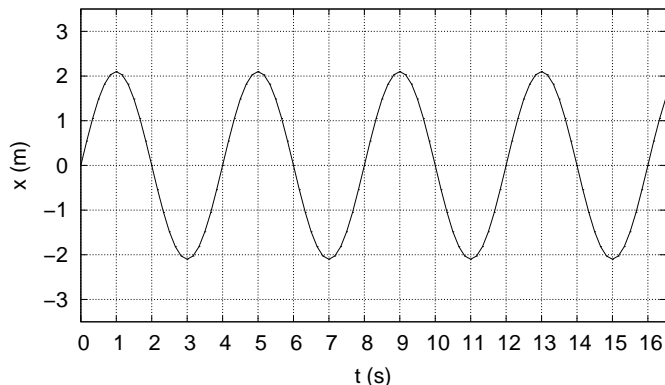


After it is pushed very slowly over the edge, it starts to roll down. At the bottom it hits another cart originally at rest with a mass of  $m_2 = 24.3$  t. The bumper mechanism locks the two carts together. What is the final common speed of the two carts? (Neglect losses due to rolling friction of the carts. The letter t stands for metric ton in the SI system.)

(in  $\text{m/s}$ )

11. A  3.89    B  4.40    C  4.97    D  5.62  
 E  6.35    F  7.17    G  8.11    H  9.16

The graph shows the x-displacement as a function of time for a particular object undergoing simple harmonic motion.



This function can be described by the following formula:  
 $x(t) = A\sin(\omega t)$ , where  $x$  and  $A$  are measured in meters,  $t$  is measured in seconds,  $\omega$  is measured in rad/s.

**2 pt** Using the graph determine the amplitude  $A$  of the oscillation.

(in m)

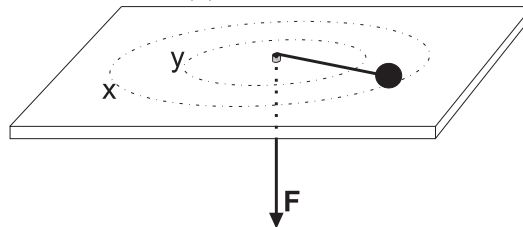
12. A  1.80    B  2.10    C  2.40    D  3.90  
 E  4.50    F  4.80    G  5.10    H  5.40

**2 pt** Determine the period  $T$  of the oscillation.

(in s)

13. A  2.80    B  3.20    C  4.00    D  4.40  
 E  5.20    F  6.80    G  7.60    H  8.00

**10 pt** A small mass  $M$  attached to a string slides in a circle (x) on a frictionless horizontal table, with the force  $\mathbf{F}$  providing the necessary tension (see figure). The force is then increased slowly and then maintained constant when  $M$  travels around in circle (y). The radius of circle (x) is twice the radius of circle (y).



▷  $M$ 's kinetic energy at  $y$  is four times that at  $x$ .  
 14. A  true    B  false    C  greater than  
 D  less than    E  equal to

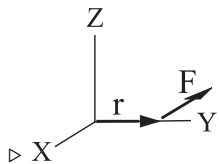
▷  $M$ 's angular velocity at  $x$  is half that at  $y$ .  
 15. A  true    B  false    C  greater than  
 D  less than    E  equal to

▷  $M$ 's angular momentum at  $x$  is .... that at  $y$ .  
 16. A  true    B  false    C  greater than  
 D  less than    E  equal to

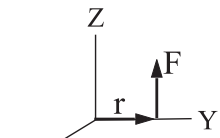
▷ While going from  $x$  to  $y$ , there is a torque on  $M$ .  
 17. A  true    B  false    C  greater than  
 D  less than    E  equal to

▷ As  $M$  moves from  $x$  to  $y$ , the work done by  $\mathbf{F}$  is .... 0.  
 18. A  true    B  false    C  greater than  
 D  less than    E  equal to

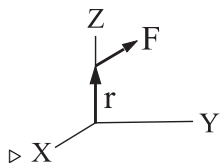
**6 pt** A body (not shown) has its center of mass (CM) at the origin. In each case below give the direction for the torque  $\tau$  with respect to the CM on the body due to force  $\mathbf{F}$  acting on the body at a location indicated by the vector  $\mathbf{r}$ .



19. A  X    B  -X    C  Y    D  -Y    E  Z  
 F  -Z



20. A  X    B  -X    C  Y    D  -Y    E  Z  
 F  -Z



21. A  X    B  -X    C  Y    D  -Y    E  Z  
 F  -Z

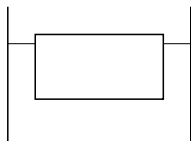
**4 pt** A 275 kg satellite is orbiting on a circular orbit 5240 km above the Earth's surface. Determine the speed of the satellite. (The mass of the Earth is  $5.97 \times 10^{24}$  kg, and the radius of the Earth is 6370 km.)  
 (in km/s)

22. A  5.86    B  6.62    C  7.48  
 D  8.45    E  9.55    F   $1.08 \times 10^1$   
 G   $1.22 \times 10^1$     H   $1.38 \times 10^1$

**4 pt** An object weighs 64.7 N in air. When it is suspended from a force scale and completely immersed in water the scale reads 23.4 N. Determine the density of the object.  
 (in  $\text{kg/m}^3$ )

23. A   $1.08 \times 10^3$     B   $1.57 \times 10^3$     C   $2.27 \times 10^3$   
 D   $3.29 \times 10^3$     E   $4.78 \times 10^3$     F   $6.93 \times 10^3$   
 G   $1.00 \times 10^4$     H   $1.46 \times 10^4$

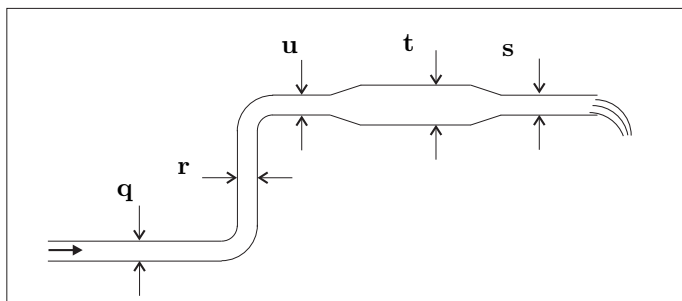
2 pt A large ice cube floats in a glass of water. (See figure.)



What happens to the water level, when the ice cube melts? (No water is lost due to evaporation.)

24.  A The water level will rise.  
 B It depends on how much water we have in the glass, and how big the ice cube is.  
 C The water level will not change.  
 D The water level will fall.

8 pt The figure illustrates the flow of an ideal fluid through a pipe of circular cross section, with diameters of 1 cm and 2 cm and with different elevations.  $p_x$  is the pressure in the pipe, and  $v_x$  is the speed of the fluid at locations  $x = q, r, s, t, \text{ or } u$ .



$\triangleright p_r$  is ....  $p_q$   
 25.  A Greater than       B Less than  
 C Equal to

$\triangleright v_q$  is ....  $v_s$   
 26.  A Greater than       B Less than  
 C Equal to

$\triangleright v_t$  is ....  $0.5v_q$   
 27.  A Greater than       B Less than  
 C Equal to

$\triangleright p_t$  is ....  $p_s$   
 28.  A Greater than       B Less than  
 C Equal to

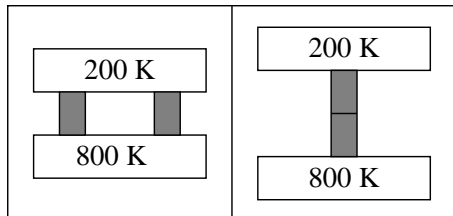
3 pt A truck horn emits a sound with a frequency of 229 Hz. The truck is moving on a straight road with a constant speed. If a person standing on the side of the road hears the horn at a frequency of 254 Hz, then what is the speed of the truck? Use 340 m/s for the speed of the sound. (in m/s)

29.  A  $2.31 \times 10^1$        B  $3.35 \times 10^1$        C  $4.85 \times 10^1$   
 D  $7.04 \times 10^1$        E  $1.02 \times 10^2$        F  $1.48 \times 10^2$   
 G  $2.14 \times 10^2$        H  $3.11 \times 10^2$

4 pt Two sounds have intensities of  $4.20 \times 10^{-8}$  and  $6.40 \times 10^{-4}$  W/m<sup>2</sup> respectively. What is the magnitude of the sound level difference between them in dB units?

30.  A 26.12       B 30.56       C 35.75       D 41.83  
 E 48.94       F 57.26       G 66.99       H 78.38

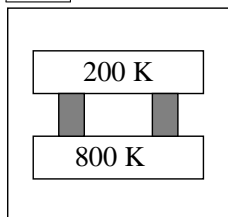
2 pt A hot (800 K) and a cold (200 K) heat reservoirs are connected to each other by two identical aluminum bars in two different ways as shown in the figure.



Compared to the left configuration, the rate of heat transfer in the right configuration is ..... as high. (Complete the sentence.)

31.  A one third  
 B three times  
 C four times  
 D one fourth  
 E one half  
 F twice

2 pt Consider the configuration shown in the figure.



Lowering the temperature of the hot reservoir from 800 K to 400 K will reduce the rate of the heat transfer by a factor of ..... (Complete the sentence.)

32.  A three  
 B four  
 C two

4 pt What is the pressure of 1.46 moles of Nitrogen gas in a 7.71 liter container, if the temperature of the gas is 41.0 °C?  
(in atm)

33.  A 3.37     B 4.88     C 7.08     D 10.26  
 E 14.88     F 21.57     G 31.28     H 45.36

10 pt Constant amount of ideal gas is kept inside a cylinder by a piston. Then the gas expands **adiabatically**. Compare the initial (i) and the final (f) physical quantities of the gas to each other.

- ▷ The temperature  $T_f$  is ...  $T_i$ .  
 34.  A equal to     B less than  
 C greater than
- ▷ The internal energy  $U_f$  is ...  $U_i$ .  
 35.  A equal to     B less than  
 C greater than
- ▷ The volume  $V_f$  is ...  $V_i$ .  
 36.  A equal to     B less than  
 C greater than
- ▷ The pressure  $p_f$  is ...  $p_i$ .  
 37.  A equal to     B less than  
 C greater than
- ▷ The entropy  $S_f$  is ...  $S_i$ .  
 38.  A equal to     B less than  
 C greater than

4 pt An ideal heat engine has an efficiency of 15.1 percent. It operates between two heat reservoirs differing in temperature by 72.8 °C. What is the temperature of the hot reservoir?  
(in K)

39.  A  $1.58 \times 10^2$      B  $2.29 \times 10^2$      C  $3.32 \times 10^2$   
 D  $4.82 \times 10^2$      E  $6.99 \times 10^2$      F  $1.01 \times 10^3$   
 G  $1.47 \times 10^3$      H  $2.13 \times 10^3$