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nagytimo@msu

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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:

- $g = 9.81 \text{ m/s}^2$
- $G = 6.67 \times 10^{-11} \text{ Nm}^2/\text{kg}^2$
- $\rho_{\text{water}} = 1000 \text{ kg/m}^3 = 1 \text{ kg/l} = 1 \text{ g/cm}^3$
- $1 \text{ atm} = 101.3 \text{ kPa} = 760 \text{ mmHg}$
- $N_A = 6.02 \times 10^{23} \text{ 1/mol}$
- $R = 8.31 \text{ J/(molK)}$
- $k_B = 1.38 \times 10^{-23} \text{ J/K}$
- $c_{\text{water}} = 4.1868 \text{ kJ/(kg}^\circ\text{C)} = 1 \text{ kcal/(kg}^\circ\text{C)}$
- $1 \text{ cal} = 4.1868 \text{ J}$
- $\sigma = 5.67 \times 10^{-8} \text{ W/(m}^2\text{K}^4)$
- $b = 2.90 \times 10^{-3} \text{ m}\cdot\text{K}$

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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 seat:

Thank you!

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1 pt Are you sitting in the seat assigned?

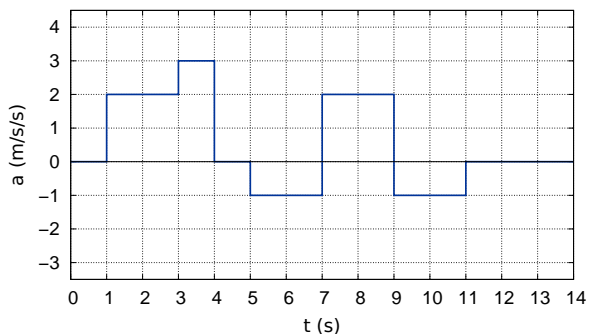
1.A  Yes, I am.

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**3 pt** A large rock is released from rest from the top of a tall building. The average speed of the rock during the first second of the fall is 5 m/s. What is the average speed of the rock during the next second? (In this question we use the approximate value of  $10 \text{ m/s}^2$  for the gravitational acceleration.)

2. **A**  30 m/s  
**B**  100 m/s  
**C**  50 m/s  
**D**  25 m/s  
**E**  20 m/s  
**F**  15 m/s  
**G**  10 m/s  
**H**  5 m/s  
**I**  0 m/s

A car is initially at rest on a straight road. The graph shows the acceleration of the car along that road as a function of time.



**3 pt** What is the speed of the car at  $t=7$  s?  
(in m/s)

3. **A**  0.0    **B**  1.0    **C**  2.0    **D**  3.0  
**E**  4.0    **F**  5.0    **G**  8.0    **H**  10.0

**4 pt** A small, single engine airplane is about to take off. The airplane becomes airborne, when its speed reaches 179.0 km/h. The conditions at the airport are ideal, there is no wind. When the engine is running at its full power, the acceleration of the airplane is  $2.60 \text{ m/s}^2$ . What is the minimum required length of the runway?

(in m)

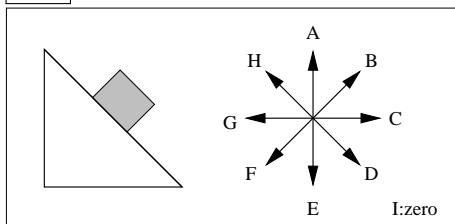
4. **A**   $4.21 \times 10^2$     **B**   $4.75 \times 10^2$     **C**   $5.37 \times 10^2$   
**D**   $6.07 \times 10^2$     **E**   $6.86 \times 10^2$     **F**   $7.75 \times 10^2$   
**G**   $8.76 \times 10^2$     **H**   $9.90 \times 10^2$

**4 pt** A baseball is projected horizontally with an initial speed of 29.6 m/s from a height of 1.81 m. At what horizontal distance will the ball hit the ground? (Neglect air friction.)

(in m)

5. **A**  8.64    **B**  9.76    **C**   $1.10 \times 10^1$   
**D**   $1.25 \times 10^1$     **E**   $1.41 \times 10^1$     **F**   $1.59 \times 10^1$   
**G**   $1.80 \times 10^1$     **H**   $2.03 \times 10^1$

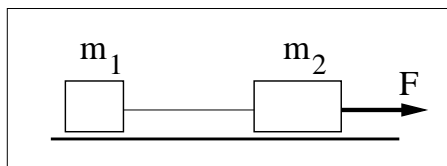
3 pt A block is at rest on a frictional incline. (See figure.)



Which vector best represents the direction of the force exerted by the surface on the block?

6. **A**  A  
 B  
 C  
 D  
 E  
 F  
 G  
 H  
 I: the force is zero.

Two masses,  $m_1 = 3.34$  kg and  $m_2 = 6.17$  kg are on a horizontal frictionless surface and they are connected together with a rope as shown in the figure.



4 pt The rope connecting the two masses will snap, if the tension in it exceeds 65.0 N. What is the maximum value of the force  $F$  which can be applied on the right hand side? (in N)

7. **A**   $1.28 \times 10^2$     **B**   $1.85 \times 10^2$     **C**   $2.68 \times 10^2$   
  $3.89 \times 10^2$     **E**   $5.64 \times 10^2$     **F**   $8.18 \times 10^2$   
  $1.19 \times 10^3$     **H**   $1.72 \times 10^3$

**3 pt** There are 149 steps between the ground floor and the sixth floor in a building. Each step is 16.7 cm tall. It takes 4 minutes and 14 seconds for a person with a mass of 78.8 kg to walk all the way up. How much work did the person do? (in J)

8.    **A**   $1.70 \times 10^4$     **B**   $1.92 \times 10^4$     **C**   $2.17 \times 10^4$   
      **D**   $2.46 \times 10^4$     **E**   $2.78 \times 10^4$     **F**   $3.14 \times 10^4$   
      **G**   $3.54 \times 10^4$     **H**   $4.00 \times 10^4$
- 

**3 pt** What was the average power performed by the person during the walk? (in W)

9.    **A**   $7.57 \times 10^1$     **B**   $8.56 \times 10^1$     **C**   $9.67 \times 10^1$   
      **D**   $1.09 \times 10^2$     **E**   $1.23 \times 10^2$     **F**   $1.40 \times 10^2$   
      **G**   $1.58 \times 10^2$     **H**   $1.78 \times 10^2$
- 

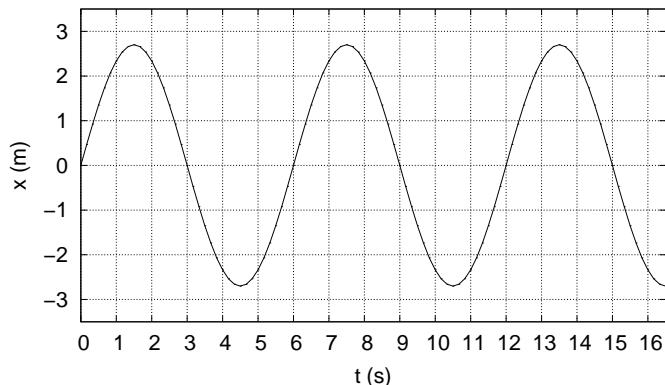
**4 pt** An airplane is flying with a speed of 377 km/h at a height of 2250 m above the ground. A parachutist whose mass is 88.1 kg, jumps out of the airplane, opens the parachute and then lands on the ground with a speed of 3.65 m/s. How much energy was dissipated on the parachute by the air friction? (in MJ)

10. **A**  2.43                    **B**  3.03                    **C**  3.79  
      **D**  4.74                    **E**  5.93                    **F**  7.41  
      **G**  9.26                    **H**   $1.16 \times 10^1$
- 

**3 pt** A 898 kg automobile slides across an icy street at a speed of 58.1 km/h and collides with a parked car. The two cars lock up and they slide together with a speed of 25.9 km/h. What is the mass of the parked car? (in kg)

11. **A**   $1.12 \times 10^3$     **B**   $1.40 \times 10^3$     **C**   $1.74 \times 10^3$   
      **D**   $2.18 \times 10^3$     **E**   $2.73 \times 10^3$     **F**   $3.41 \times 10^3$   
      **G**   $4.26 \times 10^3$     **H**   $5.32 \times 10^3$
-

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**  2.70    **D**  3.60  
**E**  4.50    **F**  5.10    **G**  5.70    **H**  6.00

**2 pt** Determine the frequency of the oscillation.

(in Hz)

13. **A**   $2.60 \times 10^{-2}$     **B**   $3.77 \times 10^{-2}$     **C**   $5.47 \times 10^{-2}$   
**D**   $7.93 \times 10^{-2}$     **E**   $1.15 \times 10^{-1}$     **F**   $1.67 \times 10^{-1}$   
**G**   $2.42 \times 10^{-1}$     **H**   $3.50 \times 10^{-1}$

**3 pt** An object is performing simple harmonic motion. The maximum value of the object's speed is 2.47 m/s and the maximum value of its acceleration is 8.52 m/s<sup>2</sup>. Determine the amplitude of the motion.

(in m)

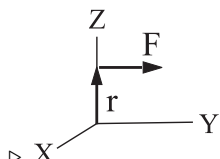
14. **A**   $7.16 \times 10^{-1}$     **B**   $8.09 \times 10^{-1}$     **C**   $9.14 \times 10^{-1}$   
**D**  1.03    **E**  1.17    **F**  1.32  
**G**  1.49    **H**  1.68

**3 pt** Determine the angular frequency of the motion.

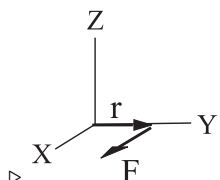
(in 1/s)

15. **A**   $2.56 \times 10^{-1}$     **B**   $3.71 \times 10^{-1}$     **C**   $5.38 \times 10^{-1}$   
**D**   $7.80 \times 10^{-1}$     **E**  1.13    **F**  1.64  
**G**  2.38    **H**  3.45

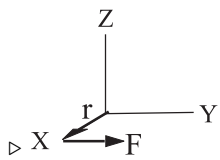
6 pt A body (not shown) has its center of mass (CM) at the origin. In each case below give the direction for the torque  $\tau$  with respect to the CM on the body due to force  $\mathbf{F}$  acting on the body at a location indicated by the vector  $\mathbf{r}$ .



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

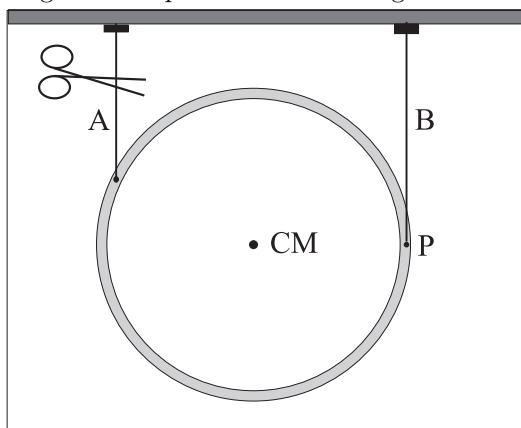


17. A  X    B  -X    C  Y    D  -Y    E  Z  
 F  -Z



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

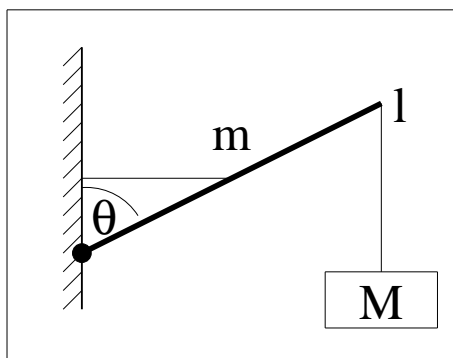
4 pt A thin circular hoop with radius  $r$  and mass  $m$  is suspended vertically by two thin strings, A and B as shown in the figure. The center of the mass of the hoop is at the same height as the point P where string B is attached.



Which of the equations below represents the initial angular acceleration  $\alpha$  of the hoop when the string A is cut? (Hint: Use the parallel axis theorem.)

19. A   $g/r$   
 B   $mgr$   
 C   $mg/(2r)$   
 D   $(2g)/r$   
 E   $mgr^2$   
 F   $g/(2r)$   
 G   $mg/r$

A crate with a mass of  $M = 55.5$  kg is suspended by a rope from the endpoint of a uniform boom. The boom has a mass of  $m = 110$  kg and a length of  $l = 7.73$  m. The midpoint of the boom is supported by another rope which is horizontal and is attached to the wall as shown in the figure.



**2 pt** The boom makes an angle of  $\theta = 66.1^\circ$  with the vertical wall. Calculate the tension in the vertical rope.  
(in N)

- 20.** A   $1.23 \times 10^2$     B   $1.79 \times 10^2$     C   $2.59 \times 10^2$   
D   $3.75 \times 10^2$     E   $5.44 \times 10^2$     F   $7.89 \times 10^2$   
G   $1.14 \times 10^3$     H   $1.66 \times 10^3$

**3 pt** What is the tension in the horizontal rope?  
(in N)

- 21.** A   $2.50 \times 10^3$     B   $3.13 \times 10^3$     C   $3.91 \times 10^3$   
D   $4.89 \times 10^3$     E   $6.12 \times 10^3$     F   $7.64 \times 10^3$   
G   $9.56 \times 10^3$     H   $1.19 \times 10^4$

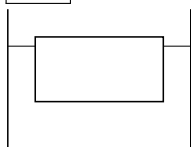
**4 pt** A 345 kg satellite is orbiting on a circular orbit 7375 km above the Earth's surface. Determine the speed of the satellite. (The mass of the Earth is  $5.97 \times 10^{24}$  kg, and the radius of the Earth is 6370 km.)  
(in km/s)

- 22.** A  4.76    B  5.38    C  6.08  
D  6.87    E  7.77    F  8.78  
G  9.92    H   $1.12 \times 10^1$

**4 pt** Glucose solution is administered to a patient in a hospital. The density of the solution is 1.293 kg/l. If the blood pressure in the vein is 35.2 mmHg, then what is the minimum necessary height of the IV bag above the position of the needle?  
(in cm)

- 23.** A  27.0    B  31.6    C  37.0    D  43.3  
E  50.6    F  59.2    G  69.3    H  81.1

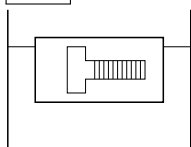
2 pt A large ice cube floats in a glass of water.



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

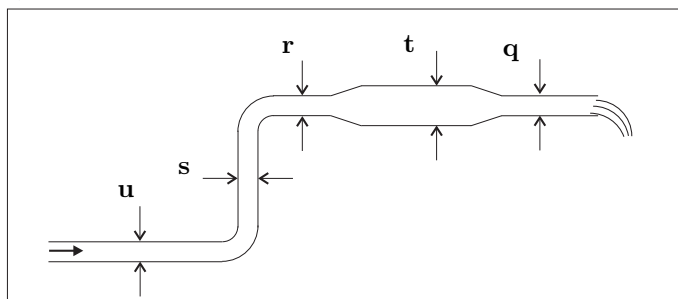
2 pt A large ice cube floats in a glass of water.



There is a steel bolt frozen inside the ice cube. What happens to the water level when all the ice melts? (No water is lost due to evaporation.)

25.  A The water level will rise.  
 B The water level will fall.  
 C The water level will not change.  
 D Without knowing the mass of the bolt, we cannot answer this question.

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  $x = q, r, s, t, \text{ or } u$ .



▷  $p_q$  is ....  $p_t$   
 26.  A Greater than  B Less than  
 C Equal to

▷  $v_u$  is ....  $v_r$   
 27.  A Greater than  B Less than  
 C Equal to

▷  $p_s$  is ....  $p_q$   
 28.  A Greater than  B Less than  
 C Equal to

▷  $v_t$  is ....  $0.5v_u$   
 29.  A Greater than  B Less than  
 C Equal to

3 pt You are watching a lightning storm through your window. You see a big flash of light and you start counting the seconds: one potato, two potatoes, three potatoes ... You hear loud thunder when you are at 15 in your counting. If sound travels one kilometer in three seconds, then how far is the storm from you? (in km)

30.  A 2.28  B 2.67  C 3.12  D 3.65  
 E 4.27  F 5.00  G 5.85  H 6.84



**4 pt** A rock band uses a wall built out of 37 identical speakers. If one single speaker can produce a sound level of 91.5 dB in the front row area, then what is the sound level produced by the whole wall?

(in dB)

- 31.** A  107.2      B  155.4      C  225.4  
D  326.8      E  473.8      F  687.0  
G  996.2      H  1444.4
- 

**3 pt** What is the pressure of 1.16 moles of Nitrogen gas in a 4.68 liter container, if the temperature of the gas is 42.4 °C?

(in atm)

- 32.** A  3.48      B  3.94      C  4.45      D  5.02  
E  5.68      F  6.42      G  7.25      H  8.19
- 

**4 pt** The height of the Eiffel tower is 321 m during the Summer when the temperature is 26.6 °C. What is the magnitude of the change in the height of the tower, when the temperature cools down to -13.3 °C during the Winter? The coefficient of linear expansion of the tower's material is  $1.14 \times 10^{-5} \text{ 1/C}^\circ$ .

(in cm)

- 33.** A   $1.29 \times 10^1$       B   $1.46 \times 10^1$       C   $1.65 \times 10^1$   
D   $1.86 \times 10^1$       E   $2.11 \times 10^1$       F   $2.38 \times 10^1$   
G   $2.69 \times 10^1$       H   $3.04 \times 10^1$
- 

**3 pt** A Stirling-engine is used in the heat-pump mode to heat a house. The engine maintains a temperature of 22.7 °C inside the house. The temperature of the Earth loop is 10.1 °C. (The Earth loop buried deep under the ground is the cold reservoir of this heat pump.) What is the coefficient of performance of this heat pump?

- 34.** A  2.53      B  3.66      C  5.31  
D  7.70      E   $1.12 \times 10^1$       F   $1.62 \times 10^1$   
G   $2.35 \times 10^1$       H   $3.40 \times 10^1$
- 

**3 pt** If the power of the electric motor driving the heat pump is 180 W, then what is the rate at which heat is delivered to the house?

(in W)

- 35.** A   $1.41 \times 10^3$       B   $1.65 \times 10^3$       C   $1.93 \times 10^3$   
D   $2.26 \times 10^3$       E   $2.64 \times 10^3$       F   $3.09 \times 10^3$   
G   $3.61 \times 10^3$       H   $4.23 \times 10^3$
-