Nagy,

Tibor

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

120 minute long closed book exam.

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

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

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

Thank you and good luck!

Posssibly useful constants:

- $g = 9.81$ m/s^2
- $G = 6.67 \times 10^{-11}$ Nm^2/kg^2
- $\rho_{\text{water}} = 1000$ kg/m^3 = 1 kg/l = 1 g/cm^3
- 1 atm = 101.3 kPa = 760 mmHg
- $N_A = 6.02\times10^{23}$ 1/mol
- $R = 8.31$ J/(molK)
- $k_B = 1.38\times10^{-23}$ J/K
- $c_{\text{water}} = 4.1868$ kJ/(kg°C) = 1 kcal/(kg°C)
- 1 cal = 4.1868 J
- $\sigma = 5.67\times10^{-8}$ W/(m^{2}K^4)
- $b = 2.90\times10^{-3}$ m·K

Posssibly useful Moments of Inertia:

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

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Please, sit in seat:

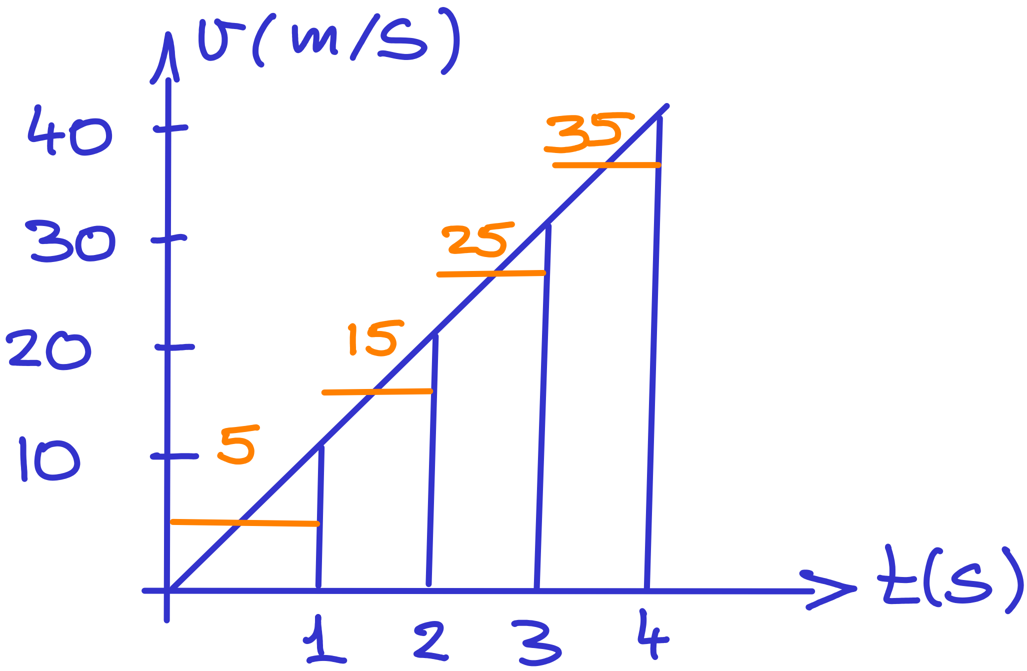
Thank you!

1 pt Are you sitting in the seat assigned?

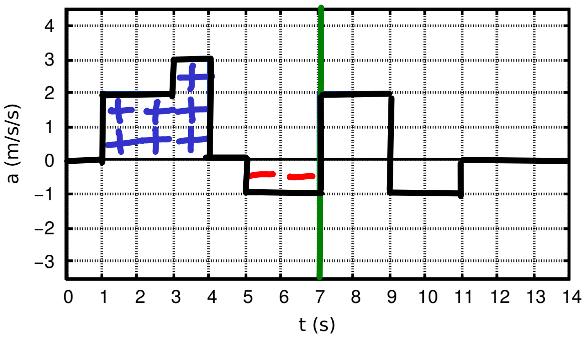
1.A ◯ Yes, I am.

$\boxed{\textit{3 pt}}$ 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 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.



acceleration:

$$a = \frac{\Delta v}{\Delta t} \Rightarrow$$

$$\Rightarrow \Delta v = \underbrace{a \cdot \Delta t}_{\text{area under}}$$

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

Initial speed: $v_0 = 0\,m/s$ i.e. rest.

Change in speed: area under the a-vs-t plot:

$$v = v_0 + \Delta v = 0 + 7 - 2 = 5\,m/s.$$

$\boxed{4\ pt}$ 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 m/s^2. What is the minimum required length of the runway?
(in m*)*

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

Conversion between km/h and m/s:

3.6 km/h = 1 m/s

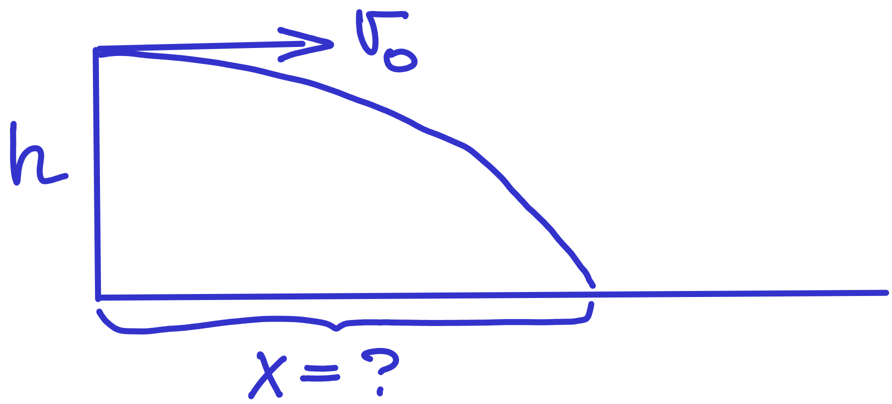
therefore 179 km/h = 49.72 m/s.

$$v^2 = 2ad \Rightarrow d = \frac{v^2}{2a}$$

$$d = \frac{49.72^2}{2 \cdot 2.60} = 475.4\,\text{m}$$

$\boxed{4\ pt}$ 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**◯ 1.10×10^1 **D**◯ 1.25×10^1
E◯ 1.41×10^1 **F**◯ 1.59×10^1 **G**◯ 1.80×10^1 **H**◯ 2.03×10^1

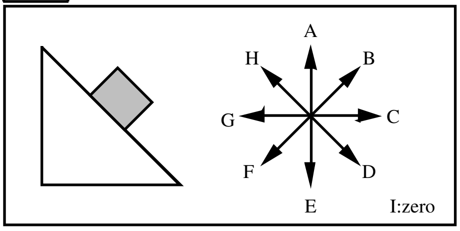


How much time does it take to fall from height h: $h = \frac{1}{2} g t^2 \Rightarrow$ $t = \sqrt{\frac{2h}{g}}$. How far do you travel horizontally in this amount of time, if your speed is v_0:

$$x = v_0 \cdot t = v_0 \sqrt{\frac{2h}{g}}$$

$$x = 29.6 \cdot \sqrt{\frac{2 \cdot 1.81}{9.81}} = 17.98\,m$$

$\boxed{\textit{3 pt}}$ A block is at rest on a frictional incline. (See figure.)

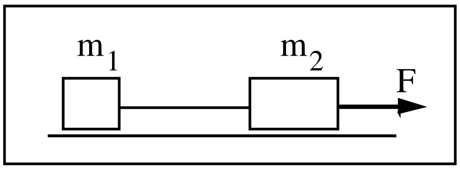


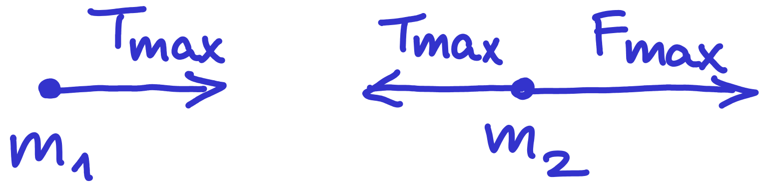
Which vector best represents the direction of the force exerted by the surface on the block?

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

The object is at rest. Therefore the weight mg must be balanced out by an equal but opposite force. Since the weight mg points vertically down, therefore the force by the incline must point vertically up.

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.





$\boxed{4\ pt}$ 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**◯ 1.28×10^2 **B**◯ 1.85×10^2 **C**◯ 2.68×10^2 **D**◯ 3.89×10^2
E◯ 5.64×10^2 **F**◯ 8.18×10^2 **G**◯ 1.19×10^3 **H**◯ 1.72×10^3

If $T_{max} = 65\,N$, then $a_{max} = T_{max}/m_1$. The two objects have the same acceleration. Newton's 2nd law for mass m_2: $F - T_{max} = m_2 \cdot a_{max} =$

$m_2 \cdot \dfrac{T_{max}}{m_1} = \dfrac{m_2}{m_1} \cdot T_{max}$ therefore

$$F = T_{max} + \frac{m_2}{m_1} \cdot T_{max} = T_{max}\left(1 + \frac{m_2}{m_1}\right)$$

$$F = T_{max} \cdot \frac{m_1 + m_2}{m_1}$$

$$F = 65 \cdot \frac{3.34 + 6.17}{3.34} = 185.1\,N$$

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**◯ 1.70×10^4 **B**◯ 1.92×10^4 **C**◯ 2.17×10^4 **D**◯ 2.46×10^4
E◯ 2.78×10^4 **F**◯ 3.14×10^4 **G**◯ 3.54×10^4 **H**◯ 4.00×10^4

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

9. **A**◯ 7.57×10^1 **B**◯ 8.56×10^1 **C**◯ 9.67×10^1 **D**◯ 1.09×10^2
E◯ 1.23×10^2 **F**◯ 1.40×10^2 **G**◯ 1.58×10^2 **H**◯ 1.78×10^2

Energy balance:

$$W_{ext} = PE = mgH = mg \cdot nh =$$
$$= 78.8 \cdot 9.81 \cdot 149 \cdot 0.167 = 1.92 \cdot 10^4 \text{ J}$$

$$\Delta t = 4\text{min } 14\text{s} = 254\text{s}$$

Power:

$$P = \frac{W}{\Delta t} = \frac{1.92 \cdot 10^4}{254} = 75.7\text{W}$$

$\boxed{4\ pt}$ 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*)*

$1\frac{m}{s} = 3.6\frac{km}{h}$

10. **A** ◯ 2.43 **B** ◯ 3.03 **C** ◯ 3.79 **D** ◯ 4.74
E ◯ 5.93 **F** ◯ 7.41 **G** ◯ 9.26 **H** ◯ 1.16×10^1

Energy balance :

$$KE_i + PE_i = KE_f + \underbrace{PE_f}_{=0} + \Delta E_{th}$$

$$\frac{1}{2}mv_i^2 + mgh = \frac{1}{2}mv_f^2 + 0 + \Delta E_{th} \Rightarrow$$

$$\Delta E_{th} = \frac{1}{2}mv_i^2 - \frac{1}{2}mv_f^2 + mgh =$$

$$= \frac{1}{2}m(v_i^2 - v_f^2) + mgh =$$

$$= \frac{1}{2}88.1(104.7^2 - 3.65^2) + 88.1 \cdot 9.81 \cdot 2250 =$$

$$= 4.82 \cdot 10^5 + 19.4 \cdot 10^5 = 2.43 \cdot 10^6 J = 2.43 MJ$$

$\boxed{3\ pt}$ 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**◯ 1.12×10^3 **B**◯ 1.40×10^3 **C**◯ 1.74×10^3 **D**◯ 2.18×10^3
E◯ 2.73×10^3 **F**◯ 3.41×10^3 **G**◯ 4.26×10^3 **H**◯ 5.32×10^3

Conservation of linear momentum:

$$m_1 \cdot v_1 + m_2 \cdot 0 = (m_1 + m_2) \cdot v_f$$

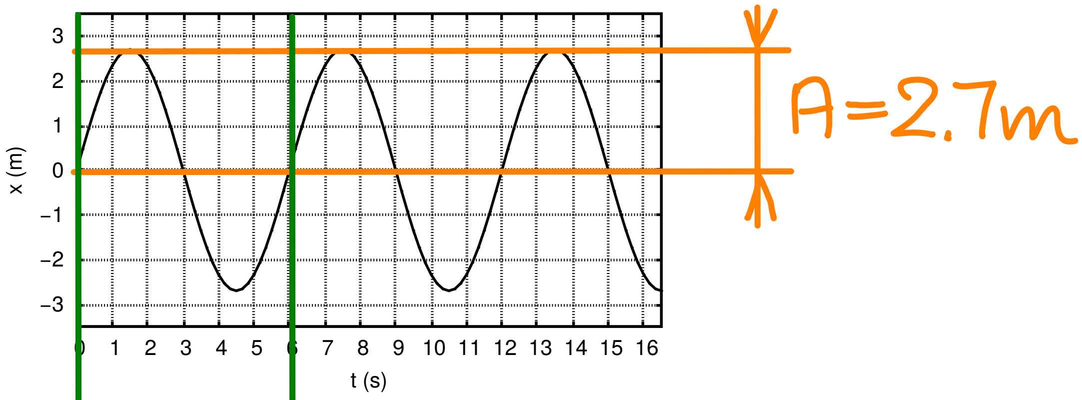
$$m_1 \cdot v_1 = m_1 \cdot v_f + m_2 \cdot v_f$$

$$m_1 \cdot v_1 - m_1 \cdot v_f = m_2 \cdot v_f$$

$$m_1 \cdot \frac{v_1 - v_f}{v_f} = m_2$$

$$m_2 = 898 \cdot \frac{58.1 - 25.9}{25.9} = 1116\,\text{kg}$$

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) = Asin(ωt), where x and A are measured in meters, t is measured in seconds, ω is measured in rad/s.

T=6s

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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

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2 pt Determine the frequency of the oscillation.
(in Hz*)*

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

Frequency: $f = \frac{1}{T} = \frac{1}{6}$ Hz $= 0.167$ Hz

$\boxed{3\ pt}$ 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^2. Determine the amplitude of the motion.
(in m*)*

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

$\boxed{3\ pt}$ Determine the angular frequency of the motion.
(in 1/s*)*

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

Simple harmonic motion:

max. speed: $v_{max} = A\omega \; (= r\omega)$

max. accel.: $a_{max} = A\omega^2 \; (= r\omega^2 = a_{cp})$

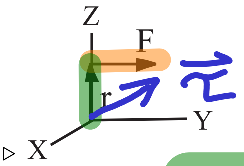
$$\frac{a_{max}}{v_{max}} = \frac{A\omega^2}{A\omega} = \omega \Rightarrow \omega = \frac{8.52}{2.47} = 3.45\,\frac{1}{s}$$

$$\frac{v_{max}^2}{a_{max}} = \frac{A^2\omega^2}{A\omega^2} = A \Rightarrow A = \frac{2.47^2}{8.52} = 0.716\,m$$

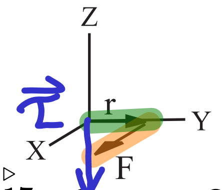
$\boxed{\textit{6 pt}}$ A body (not shown) has its center of mass (CM) at the origin. In each case below give the direction for the torque τ with respect to the CM on the body due to force **F** acting on the body at a location indicated by the vector **r**.

Torque:

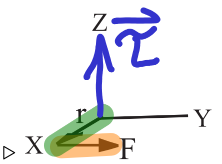
$$\vec{\tau} = \vec{r} \times \vec{F}$$



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

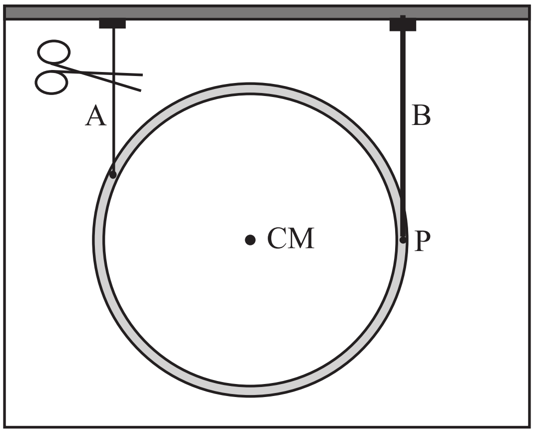


17. **A**◯ X **B**◯ -X **C**◯ Y **D**◯ -Y **E**◯ Z **F**◯ -Z



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

$\boxed{4\ pt}$ 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.



Moment of inertia of a hoop wrt the center:

$$I_{CM} = mr^2$$

Which of the equations below represents the initial angular acceleration α 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

Parallel axis theorem:

$$I_P = I_{CM} + mr^2 = 2mr^2$$

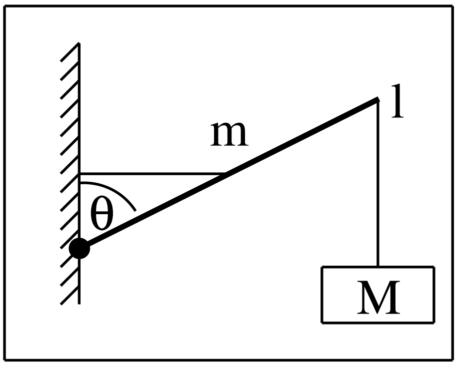
Rotational Newton's second law:

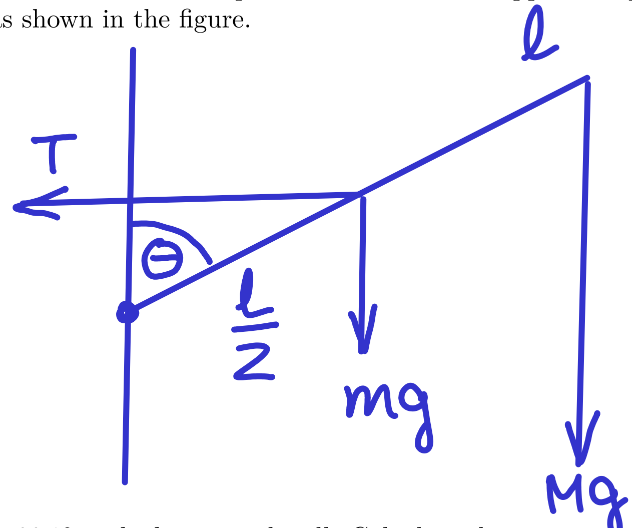
$$\tau = I \cdot \alpha$$

$$mg \cdot r = 2mr^2 \cdot \alpha$$

$$\frac{g}{(2r)} = \alpha$$

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 $\theta = 66.1°$ with the vertical wall. Calculate the tension in the vertical rope. *(in N)*

20. **A** ◯ 1.23×10^2 **B** ◯ 1.79×10^2 **C** ◯ 2.59×10^2 **D** ◯ 3.75×10^2
E ◯ 5.44×10^2 **F** ◯ 7.89×10^2 **G** ◯ 1.14×10^3 **H** ◯ 1.66×10^3

$Mg = 55.5 \cdot 9.81 =$
$= 544\,N$

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

21. **A** ◯ 2.50×10^3 **B** ◯ 3.13×10^3 **C** ◯ 3.91×10^3 **D** ◯ 4.89×10^3
E ◯ 6.12×10^3 **F** ◯ 7.64×10^3 **G** ◯ 9.56×10^3 **H** ◯ 1.19×10^4

Torque balance:

$$\underbrace{T \cdot \frac{l}{2} \cdot \cos\theta}_{\text{ccw torque}} = \underbrace{mg \cdot \frac{l}{2} \cdot \sin\theta + Mg \cdot l \cdot \sin\theta}_{\text{cw torque}}$$

$$T = (m + 2M) \cdot g \cdot \tan\theta$$

$$T = (110 + 111) \cdot 9.81 \cdot \tan(66.1°)$$

$$T = 4892\,N$$

$\boxed{\textit{4 pt}}$ 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 5.97×10^{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**◯ 1.12×10^{1}

Satellite speed:

$$v = \sqrt{\frac{GM}{r}} = \sqrt{\frac{GM}{R_E + h}} =$$

$$= \sqrt{\frac{6.67 \cdot 10^{-11} \cdot 5.97 \cdot 10^{24}}{(6370 + 7375) \cdot 1000}}$$

$$= 5382\, m/s \cong 5.38\, km/s$$

$\boxed{\textit{4 pt}}$ 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

$$p = \rho g h \Rightarrow h = \frac{p}{\rho g}$$

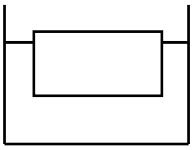
$$\rho = 1.293\ kg/l = 1{,}293\ kg/m^3$$

$$101{,}300\ Pa = 760\ mmHg$$

$$133.3\ Pa = 1\ mmHg$$

$$h = \frac{35.2 \cdot 133.3}{1{,}293 \cdot 9.81} = 0.37\ m = 37\ cm$$

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



1kg ice displaces 1kg water.
When 1kg ice melts, it gives
1 kg water ⇒ the level will not
change.

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.

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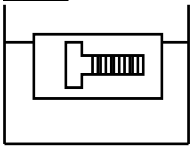
2 pt A large ice cube floats in a glass of water.

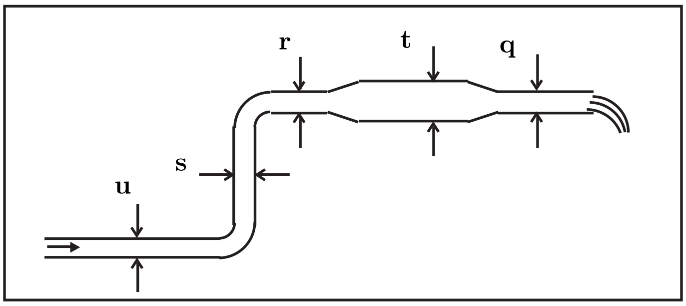


There is a steel bolt frozen inside the ice cube. What happens to the water level when all the ice melts? (No water is lost due to evaporation.)

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.

The steel bolt displaces water equivalent to its weight while it's floating in an ice cube. When the icecube melts, the bolt sinks. Then it will displace water equivalent to its volume only, therefore the water level will fall.

$\boxed{8\ pt}$ 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, 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

→ $p_q < p_t$: when the fluid speeds up, the pressure drops.

→ $v_u = v_r$: continuity: same cross section same speed.

→ $p_s > p_q$: when you climb in a fluid, the pressure drops. When you dive, the pressure increases.

→ $v_t < 0.5 v_u$ b/c $v_t = 0.25 v_u$ due to continuity: $A_t \cdot v_t = A_u \cdot v_u$

$\boxed{\textit{3 pt}}$ 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

If sound travels one kilometer in three seconds, then in 15 seconds it travels 5 kilometers.

$\boxed{4\ pt}$ 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

$$S_{37} = 10 \cdot \log(37 \cdot I_1 / I_0) =$$

$$= 10 \cdot \log(37) + \underbrace{10 \cdot \log(I_1/I_0)}_{91.5\,dB} =$$

$$= 15.68\ dB + 91.5\ dB = 107.18\ dB$$

$\boxed{3\ pt}$ 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

Ideal gas law: $pV = nRT$

$R = 8.31\ J/(molK)$

$T = 42.4°C = 315.4\ K$

$V = 4.68\ l = 4.68 \cdot 10^{-3}\ m^3$

$n = 1.16\ mol$

$$p = \frac{nRT}{V} = \frac{1.16 \cdot 8.31 \cdot 315.4}{4.68 \cdot 10^{-3}}$$

$p = 6.496 \cdot 10^{5}\ Pa = 6.41\ atm$

$(101{,}300\ Pa = 1\ atm)$

$\boxed{\textit{4 pt}}$ 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 1.14×10^{-5} 1/C°.
(in cm*)*

33. **A**◯ 1.29×10^1 **B**◯ 1.46×10^1 **C**◯ 1.65×10^1 **D**◯ 1.86×10^1
E◯ 2.11×10^1 **F**◯ 2.38×10^1 **G**◯ 2.69×10^1 **H**◯ 3.04×10^1

Heat expansion:

$\Delta l = \alpha \cdot l_0 \cdot \Delta T$

$\alpha = 1.14 \cdot 10^{-5}$ 1/°C

$\Delta T = 26.6 - (-13.3) = 39.9$ °C

$l_0 = 321$ m

$\Delta l = 1.14 \cdot 10^{-5} \cdot 321 \cdot 39.9 = 0.146$ m

$\Delta l = 14.6$ cm

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◯ 1.12×10^1 **F**◯ 1.62×10^1 **G**◯ 2.35×10^1 **H**◯ 3.40×10^1

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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**◯ 1.41×10^3 **B**◯ 1.65×10^3 **C**◯ 1.93×10^3 **D**◯ 2.26×10^3
E◯ 2.64×10^3 **F**◯ 3.09×10^3 **G**◯ 3.61×10^3 **H**◯ 4.23×10^3

Heat pump: coeff. of performance:

$$K = \frac{Q_H}{W_{in}} = \frac{Q_H}{Q_H - Q_C} = \frac{T_H}{T_H - T_C}$$

Carnot

$$K = \frac{273 + 22.7}{22.7 - 10.1} = 23.5$$

$$K = \frac{Q_H}{W_{in}} = \frac{Q_H/\Delta t}{W_{in}/\Delta t} = \frac{P_H}{P_{in}}$$

$$P_H = K \cdot P_{in} = 23.5 \cdot 180\,W = 4224\,W$$

This machine heats your house with 4224W power, while it uses only 180W!