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:

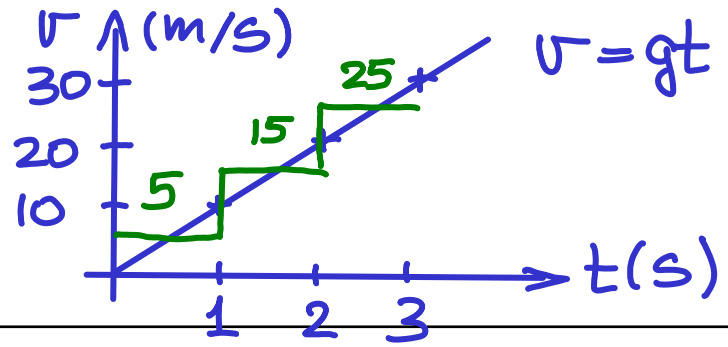
Thank you!

$\boxed{\textit{1 pt}}$ Are you sitting in the seat assigned?

1.A ◯ Yes, I am.

$\boxed{\textit{4 pt}}$ 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 third second? (In this question we use the approximate value of 10 m/s^2 for the gravitational acceleration.)

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

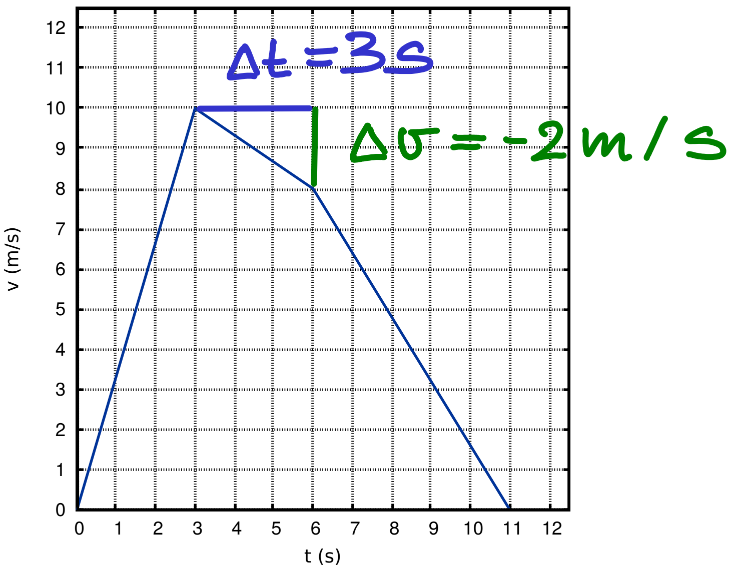


$v = gt$; $g = 10\, m/s^2$

The average speeds in free fall go as 5, 15, 25, 35, ... m/s over the one second time intervals.

(The 1:3:5:7:9... pattern was first observed and explained by Galileo Galilei.)

A car is waiting at an intersection. When the traffic light turns green, the car starts moving. After some time the car comes to rest at another traffic light. The figure below shows the velocity of the car as a function of time.



One can clearly identify three different stages of this motion.

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2 pt What is the acceleration of the car during the second stage of the motion?
(in m/s^2*)*

3. **A**◯ -2.00 **B**◯ -1.00 **C**◯ -0.667 **D**◯ 0
E◯ 0.400 **F**◯ 0.500 **G**◯ 0.667 **H**◯ 2.00

$$a = \frac{\Delta v}{\Delta t} = \frac{-2\,m/s}{3s} = -0.67\frac{m}{s^2}$$

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2 pt What is the total distance travelled by the car between the two traffic lights?
(in m*)*

4. **A**◯ 26.4 **B**◯ 35.1 **C**◯ 46.6 **D**◯ 62.0 **E**◯ 82.5 **F**◯ 110. **G**◯ 146 **H**◯ 194

Distance travelled is the area under the v-t graph:

$$D = \frac{0+10}{2}\cdot 3 + \frac{10+8}{2}\cdot 3 + \frac{8+0}{2}\cdot 5 =$$

$$= 15 + 27 + 20 = 62\,m$$

A baseball is projected horizontally with an initial speed of 17.9 m/s from a height of 2.33 m. (Please, neglect air friction in this question.)

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2 pt What is the horizontal component of the ball's velocity, when the ball hits the ground? *(in* `m/s`*)*

5. **A**◯ 1.53×10^1 **B**◯ 1.79×10^1 **C**◯ 2.09×10^1 **D**◯ 2.45×10^1
E◯ 2.87×10^1 **F**◯ 3.35×10^1 **G**◯ 3.92×10^1 **H**◯ 4.59×10^1

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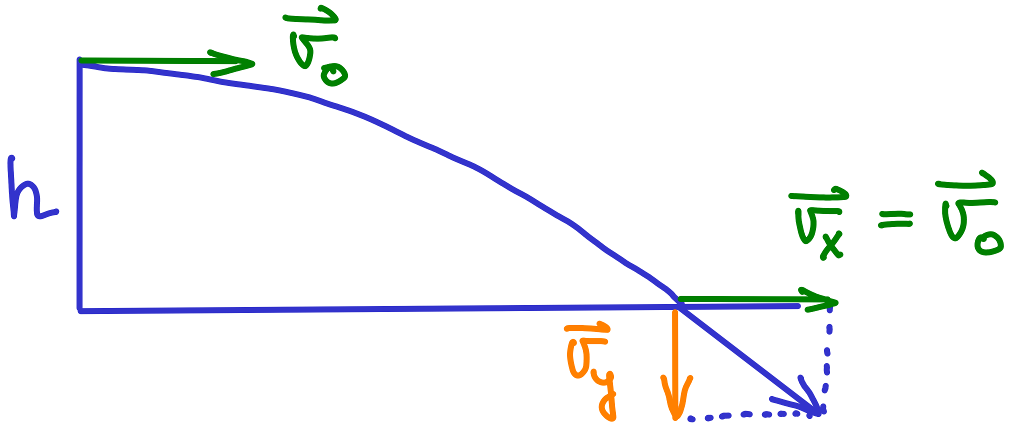
2 pt What is the magnitude of the vertical component of the ball's velocity, when the ball hits the ground? *(in* `m/s`*)*

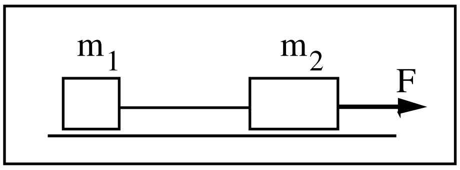
6. **A**◯ 3.22 **B**◯ 4.66 **C**◯ 6.76 **D**◯ 9.80
E◯ 1.42×10^1 **F**◯ 2.06×10^1 **G**◯ 2.99×10^1 **H**◯ 4.33×10^1

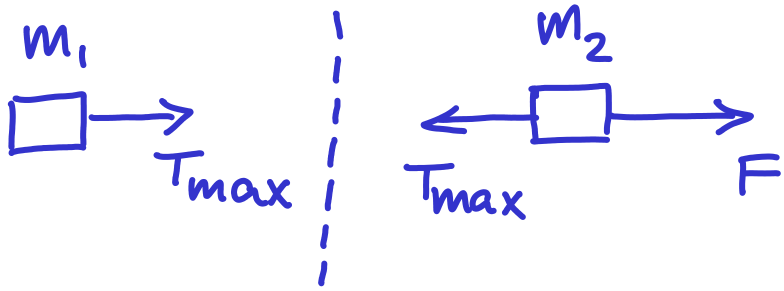


$$v_x = v_0 = 17.9 \text{ m/s}$$

$$v_y = \sqrt{2gh} = \sqrt{2 \cdot 9.81 \cdot 2.33} = 6.76 \text{ m/s}$$

Two masses, $m_1 = 3.20$ kg and $m_2 = 5.98$ kg are on a horizontal frictionless surface and they are connected together with a rope as shown in the figure.





$\boxed{2\ pt}$ The rope will snap if the tension in it exceeds 75.0 N. What is the maximum value of the force **F** which can be applied?
(in `N`*)*

7. **A**◯ 3.89×10^1 **B**◯ 5.17×10^1 **C**◯ 6.88×10^1 **D**◯ 9.15×10^1
E◯ 1.22×10^2 **F**◯ 1.62×10^2 **G**◯ 2.15×10^2 **H**◯ 2.86×10^2

$\boxed{2\ pt}$ What is the acceleration of the whole system, when this maximum force is applied?
(in `m/s^2`*)*

8. **A**◯ 2.34×10^1 **B**◯ 2.65×10^1 **C**◯ 2.99×10^1 **D**◯ 3.38×10^1
E◯ 3.82×10^1 **F**◯ 4.32×10^1 **G**◯ 4.88×10^1 **H**◯ 5.51×10^1

Newton's 2nd law for m_1:

$$T_{max} = m_1 \cdot a_{max} \Rightarrow a_{max} = \frac{T_{max}}{m_1}$$

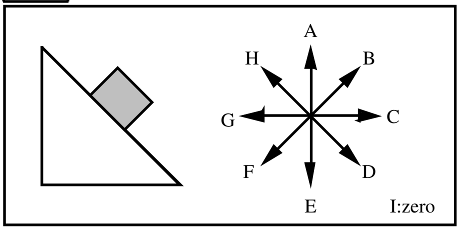
$$a_{max} = \frac{75\,N}{3.2\,kg} = 23.4\ m/s^2$$

Newton's 2nd law for the whole system:

$$F = (m_1 + m_2) \cdot a_{max}$$

$$F = (3.20 + 5.98)\,kg \cdot 23.4 \frac{m}{s^2} = 215\,N$$

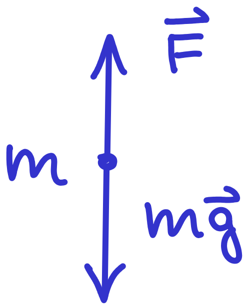
$\boxed{3\ pt}$ A block is at rest on a frictional incline. (See figure.)



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

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

Since the block is at rest:



The normal component of $\vec{F}$ is called normal force $\vec{N}$; the tangential or parallel component is called friction $\vec{f}$. In this case the friction is static: $\vec{f}_s$ because the block is sitting at rest on the incline.

Force $\vec{F}$ is one single force!

$\boxed{4\ pt}$ An athlete, swimming at a constant speed, covers a distance of 226 m in a time period of 5 minutes and 31 seconds. The drag force exerted by the water on the swimmer is 70.0 N. What is the power the swimmer must provide to overcome that drag force.
(in W*)*

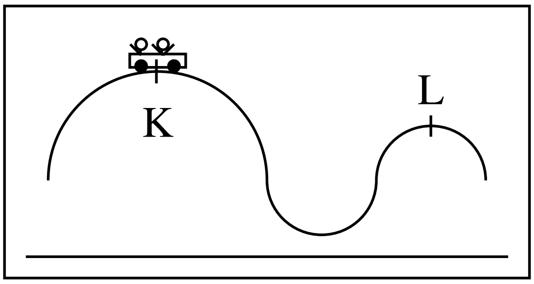
10. **A**◯ 1.57×10^{1} **B**◯ 2.27×10^{1} **C**◯ 3.30×10^{1} **D**◯ 4.78×10^{1}
E◯ 6.93×10^{1} **F**◯ 1.00×10^{2} **G**◯ 1.46×10^{2} **H**◯ 2.11×10^{2}

Power : $P = \vec{F} \cdot \vec{v} = Fv$ (since $\cos 0° = 1$)

$v = \frac{d}{t}$ (motion with constant speed)

$$P = F \cdot \frac{d}{t} = 70N \cdot \frac{226m}{331s} = 47.8W$$

On a roller coaster ride the total mass of a cart - with two passengers included - is 316 kg. Peak **K** is at 46.6 m above the ground and peak **L** is at 24.0 m. At location **K** the speed of the cart is 15.3 m/s, and at location **L** it is 12.4 m/s. (The wheel mechanism on roller coaster carts always keeps the carts safely on the rail.)



Energy balance:

$TE_K = TE_L + \Delta E_{th}$

Mechanical energy:

$TE = PE + KE$

4 pt How much mechanical energy is lost due to friction between the two peaks?
(in J)

11. **A** ◯ 8.90×10^3 **B** ◯ 1.29×10^4 **C** ◯ 1.87×10^4 **D** ◯ 2.71×10^4
E ◯ 3.94×10^4 **F** ◯ 5.71×10^4 **G** ◯ 8.28×10^4 **H** ◯ 1.20×10^5

Everything combined:

$PE_K + KE_K = PE_L + KE_L + \Delta E_{th}$

$mgh_K + \frac{1}{2}mv_K^2 = mgh_L + \frac{1}{2}mv_L^2 + \Delta E_{th} \Rightarrow$

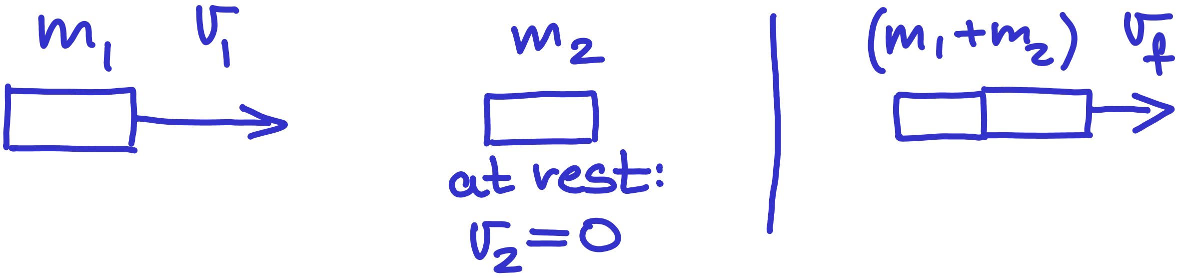
$\Rightarrow \Delta E_{th} = mg(h_K - h_L) + \frac{1}{2}m(v_K^2 - v_L^2)$

$\Delta E_{th} = 316 \cdot 9.81 \cdot (46.6 - 24.0) +$

$+ \frac{1}{2} \cdot 316 \cdot (15.3^2 - 12.4^2) = 8.28 \cdot 10^4 \text{ J}$

$\boxed{\textit{4 pt}}$ A 927 kg automobile slides across an icy street at a speed of 62.7 km/h and collides with a parked car. The two cars lock up and they slide together with a speed of 29.7 km/h. What is the mass of the parked car?
(in kg*)*

12. **A**◯ 6.59×10^2 **B**◯ 8.24×10^2 **C**◯ 1.03×10^3 **D**◯ 1.29×10^3
E◯ 1.61×10^3 **F**◯ 2.01×10^3 **G**◯ 2.51×10^3 **H**◯ 3.14×10^3



Conservation of momentum:

$$m_1 v_1 + \underbrace{m_2 v_2}_{=0} = (m_1 + m_2)\, v_f$$

$$m_1 v_1 = m_1 v_f + m_2 v_f$$

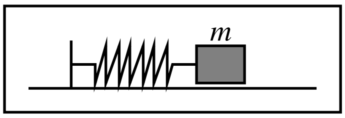
$$m_1 v_1 - m_1 v_f = m_2 v_f$$

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

$$m_2 = 927\,\text{kg} \cdot \frac{62.7\,\text{km/h} - 29.7\,\text{km/h}}{29.7\,\text{km/h}}$$

$$m_2 = 1030\,\text{kg}$$

2 pt A mass of $m = 1.41$ kg connected to a spring oscillates on a horizontal frictionless surface as shown in the figure.



Simple Harmonic Motion:
$x(t) = A \cdot \cos(\omega t)$

The equation of motion of the mass is given by
$x = 0.333 \cos(1.02t)$
where the position x is measured in meters, the time t in seconds. Determine the period of the motion.
(in s*)*

$\omega = \frac{2\pi}{T} \Rightarrow T = \frac{2\pi}{\omega}$

13. **A**◯ 5.45 **B**◯ 6.16 **C**◯ 6.96 **D**◯ 7.87
E◯ 8.89 **F**◯ 1.00×10^{1} **G**◯ 1.13×10^{1} **H**◯ 1.28×10^{1}

$T = 6.16\,s$

$v_{max} = A\omega$

2 pt What is the maximum speed reached by the mass?
(in m/s*)*

$v_{max} = 0.34\,\frac{m}{s}$

14. **A**◯ 1.84×10^{-1} **B**◯ 2.08×10^{-1} **C**◯ 2.35×10^{-1} **D**◯ 2.66×10^{-1}
E◯ 3.01×10^{-1} **F**◯ 3.40×10^{-1} **G**◯ 3.84×10^{-1} **H**◯ 4.34×10^{-1}

$k = m\omega^2$
$k = 1.41 \cdot 1.02^2$

2 pt Determine the spring constant.
(in N/m*)*

$k = 1.47\ N/m$

15. **A**◯ 4.81×10^{-1} **B**◯ 6.01×10^{-1} **C**◯ 7.51×10^{-1} **D**◯ 9.39×10^{-1}
E◯ 1.17 **F**◯ 1.47 **G**◯ 1.83 **H**◯ 2.29

Hooke's law: $F = k \cdot x$

$F_{max} = k \cdot x_{max} = k \cdot A \quad (\leftarrow x_{max} = A)$

Newton's 2nd law:

$F_{max} = m \cdot a_{max} = m A \omega^2 \quad (\leftarrow a_{max} = A\omega^2)$

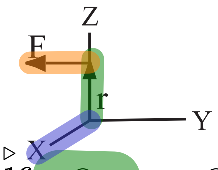
Let's combine them together:

$kA = m A \omega^2$

$k = m\omega^2$

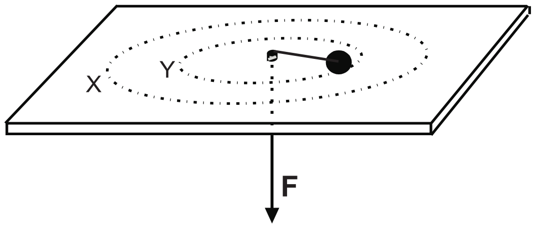
$\boxed{\textit{4 pt}}$ An extended body (not shown in the figure) has its center of mass (CM) at the origin of the reference frame. In the case below give the direction for the torque τ with respect to the CM on the body due to force **F** acting on the body at a location indicated by the vector **r**.

Torque: $\vec{\tau} = \vec{r} \times \vec{F}$
and RHR



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

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



▷ As M moves from Y to X, the work done by **F** is .... 0.
17. **A**◯ true **B**◯ false **C**◯ greater than **D**◯ less than **E**◯ equal to

▷ While going from Y to X, there is a torque on M.
18. **A**◯ true **B**◯ false **C**◯ greater than **D**◯ less than **E**◯ equal to

▷ M's kinetic energy at X is half that at Y.
19. **A**◯ true **B**◯ false **C**◯ greater than **D**◯ less than **E**◯ equal to

▷ M's angular momentum at X is .... that at Y.
20. **A**◯ true **B**◯ false **C**◯ greater than **D**◯ less than **E**◯ equal to

▷ M's angular velocity at X is half that at Y.
21. **A**◯ true **B**◯ false **C**◯ greater than **D**◯ less than **E**◯ equal to

→ $W < 0$ b/c F and displacement d points in the opposite directions

→ $\tau = 0$ b/c the force is central

→ $L_X = L_Y$ b/c $\tau = 0$ $\left(\tau = \frac{\Delta L}{\Delta t}\right)$

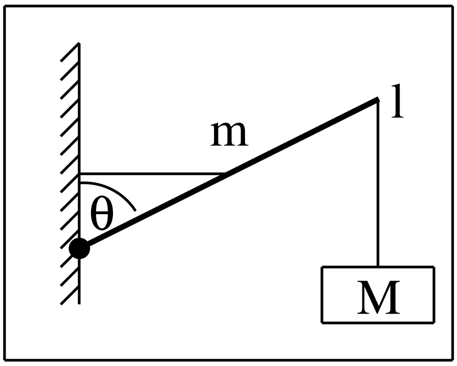
→ $\omega_X = \frac{1}{4}\omega_Y$ from $\omega = \frac{L}{I} = \frac{L}{mr^2}$

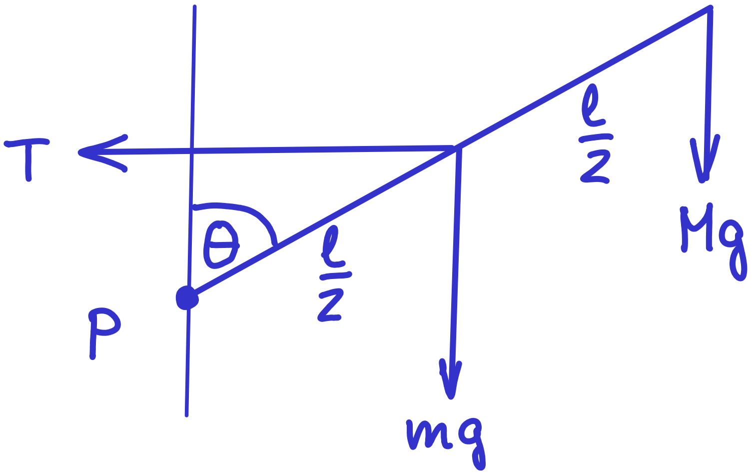
$\omega \propto \frac{1}{r^2}$

→ $KE_X = \frac{1}{4} KE_Y$ from $KE = \frac{L^2}{2I} = \frac{L^2}{2mr^2}$

$KE \propto \frac{1}{r^2}$

A crate with a mass of M = 84.5 kg is suspended by a rope from the endpoint of a uniform boom. The boom has a mass of m = 135 kg and a length of l = 7.25 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.





$\boxed{\textit{2 pt}}$ The boom makes an angle of $\theta = 65.0°$ with the vertical wall. Calculate the tension in the vertical rope.
(in N*)*

22. **A**◯ 6.23×10^2 **B**◯ 8.29×10^2 **C**◯ 1.10×10^3 **D**◯ 1.47×10^3
E◯ 1.95×10^3 **F**◯ 2.59×10^3 **G**◯ 3.45×10^3 **H**◯ 4.59×10^3

$Mg = 84.5 \cdot 9.81 =$
$= 829\,N$

$\boxed{\textit{2 pt}}$ What is the tension in the horizontal rope?
(in N*)*

23. **A**◯ 5.12×10^3 **B**◯ 6.40×10^3 **C**◯ 7.99×10^3 **D**◯ 9.99×10^3
E◯ 1.25×10^4 **F**◯ 1.56×10^4 **G**◯ 1.95×10^4 **H**◯ 2.44×10^4

Balance of the torques:

$$T \cdot \frac{l}{2} \cdot \cos\theta = mg \cdot \frac{l}{2} \sin\theta + Mg\, l \cdot \sin\theta$$

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

$$T = (135 + 2 \cdot 84.5) \cdot 9.81 \cdot \tan 65°$$

$$T = 6395\,N$$

$\boxed{4\ pt}$ A 230 kg satellite is orbiting Earth on a circular orbit with a speed of 5.71 km/s. Determine the height of the satellite above Earth's surface. (The mass of the Earth is 5.97×10^{24} kg, and the radius of the Earth is 6370 km.) *(in* `km`*)*

24. **A**◯ 3.30×10^3 **B**◯ 4.39×10^3 **C**◯ 5.84×10^3 **D**◯ 7.77×10^3
E◯ 1.03×10^4 **F**◯ 1.37×10^4 **G**◯ 1.83×10^4 **H**◯ 2.43×10^4

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satellite speed:

$$v = \sqrt{\frac{GM}{r}} \Rightarrow r = \frac{GM}{v^2}$$

$$r = \frac{6.67 \cdot 10^{-11} \cdot 5.97 \cdot 10^{24}}{5710^2} = 12{,}213 \text{ km}$$

$$h = r - R = 12{,}213 - 6370 = 5843 \text{ km}$$

$\boxed{4\ pt}$ Glucose solution is administered to a patient in a hospital. The density of the solution is 1.300 kg/l. If the blood pressure in the vein is 25.7 mmHg, then what is the minimum necessary height of the IV bag above the position of the needle?
(in cm*)*

25. **A**◯ 12.8 **B**◯ 18.5 **C**◯ 26.9 **D**◯ 38.9
E◯ 56.5 **F**◯ 81.9 **G**◯ 118.7 **H**◯ 172.2

Hydrostatic pressure:

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

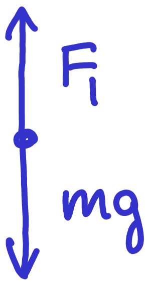
$$h = \frac{25.7\,\text{mmHg} \cdot 133.3\,\text{Pa/mmHg}}{1300\,\text{kg/m}^3 \cdot 9.81\,\text{m/s}^2}$$

$$h = 0.269\,\text{m} = 26.9\,\text{cm}$$

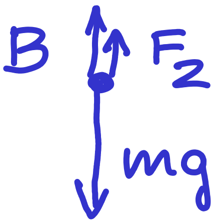
$\boxed{\textit{4 pt}}$ An object weighs 95.9 N in air. When it is suspended from a force scale and completely immersed in water the scale reads 24.4 N. Determine the density of the object.
(in kg/m^3*)*

26. **A**◯ 4.40×10^2 **B**◯ 5.49×10^2 **C**◯ 6.87×10^2 **D**◯ 8.58×10^2
E◯ 1.07×10^3 **F**◯ 1.34×10^3 **G**◯ 1.68×10^3 **H**◯ 2.10×10^3

In air:



In water:



Archimedes:

$$B = m_{fluid} \cdot g =$$
$$= \rho_f \cdot V_{obj} \cdot g$$

$$F_1 = mg \qquad F_2 + B = mg$$

$$F_1 = F_2 + B$$

$$F_1 - F_2 = B = \rho_f \cdot V_{obj} \cdot g = \rho_f \cdot \frac{m_{obj}}{\rho_{obj}} \cdot g =$$

$$= \frac{\rho_f}{\rho_{obj}} \cdot F_1 \Rightarrow \rho_{obj} = \rho_f \cdot \frac{F_1}{F_1 - F_2}$$

$$\rho_{obj} = 1000 \cdot \frac{95.9}{95.9 - 24.4} = 1341 \frac{kg}{m^3}$$

$\boxed{4\ pt}$ An Airbus A380-800 passanger airplane is cruising at constant altitude on a straight line with a constant speed. The total surface area of the two wings is 395 m^2. The average speed of the air just below the wings is 252 m/s, and it is 278 m/s just above the surface of the wings. What is the mass of the airplane? The average density of the air around the airplane is $\rho_{air} = 1.11$ kg/m^3.
(in kg*)*

27. A◯ 2.725×10^5 B◯ 3.079×10^5 C◯ 3.480×10^5 D◯ 3.932×10^5
E◯ 4.443×10^5 F◯ 5.021×10^5 G◯ 5.674×10^5 H◯ 6.411×10^5

Bernoulli principle :

$$\underbrace{\frac{1}{2}\rho v_a^2 + \rho g h_a + p_a}_{a:\ above} = \underbrace{\frac{1}{2}\rho v_b^2 + \rho g h_b + p_b}_{b:\ below}$$

since $\rho g h_a \cong \rho g h_b$ (b/c $h_a \cong h_b$)

therefore $\frac{1}{2}\rho v_a^2 + p_a = \frac{1}{2}\rho v_b^2 + p_b$

$$\frac{1}{2}\rho(v_a^2 - v_b^2) = p_b - p_a$$

Force : $F = \Delta p \cdot A = (p_b - p_a)A$

$$F = \frac{1}{2}\rho(v_a^2 - v_b^2) \cdot A$$

$$F = \frac{1}{2} \cdot 1.11 \cdot (278^2 - 252^2) \cdot 395$$

$$F = 3.02 \cdot 10^6 N$$

$$F = mg \Rightarrow m = \frac{F}{g} = 3.079 \cdot 10^5 \text{ kg} =$$

$$= 307.9 \text{ t}$$

$\boxed{4\ pt}$ Two sounds have intensities of 1.80×10^{-8} and 6.90×10^{-4} W/m^2 respectively. What is the magnitude of the sound level difference between them in dB units?

28. **A** ◯ 6.23 **B** ◯ 8.28 **C** ◯ 11.01 **D** ◯ 14.65
E ◯ 19.48 **F** ◯ 25.91 **G** ◯ 34.46 **H** ◯ 45.84

$$S = 10 \log\left(\frac{6.9 \cdot 10^{-4}}{1.8 \cdot 10^{-8}}\right) = 45.84\,\text{dB}$$

$\boxed{4\ pt}$ A bag filled with lead shots is dropped from a height of h = 25.1 m. The total mass of the bag is m = 515 g. What is the increase in the temperature of the lead shots, after the bag hits the ground? (The specific heat of lead is c = 130 J/kgK.)
(in K*)*

29. **A**◯ 7.76×10^{-1} **B**◯ 9.70×10^{-1} **C**◯ 1.21 **D**◯ 1.52
E◯ 1.89 **F**◯ 2.37 **G**◯ 2.96 **H**◯ 3.70

Energy balance :

$$PE_i = \Delta E_{th}$$

$$mgh = cm\Delta T$$

$$\frac{gh}{c} = \Delta T$$

$$\Delta T = \frac{9.81 \cdot 25.1}{130} = 1.89 K$$

$\boxed{4\ pt}$ What is the pressure of 2.03 moles of Nitrogen gas in a 7.85 liter container, if the temperature of the gas is 30.5 °C?
(in atm*)*

30. **A**◯ 3.06 **B**◯ 4.44 **C**◯ 6.44 **D**◯ 9.34
E◯ 13.54 **F**◯ 19.64 **G**◯ 28.47 **H**◯ 41.29

Ideal gas law: $pV = nRT$

$n = 2.03\ \text{mol}$

$V = 7.85\ \ell = 0.00785\ m^3$

$T = 30.5°C = 303.5\ K$

$R = 8.31\ J/(mol K)$

$$p = \frac{nRT}{V} = \frac{2.03 \cdot 8.31 \cdot 303.5}{0.00785}$$

$p = 6.52 \cdot 10^5\ Pa = 6.44\ atm$

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

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

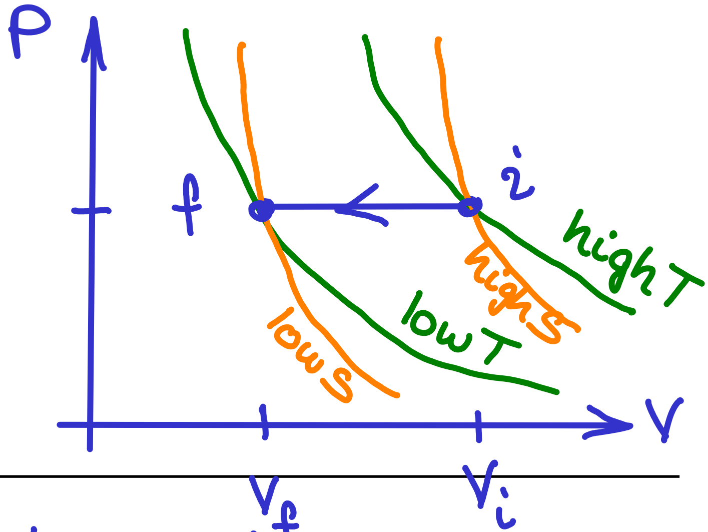
▷ The pressure p_f is ... p_i.
31. **A**◯ equal to **B**◯ less than **C**◯ greater than

▷ The internal energy U_f is ... U_i.
32. **A**◯ equal to **B**◯ less than **C**◯ greater than

▷ The temperature T_f is ... T_i.
33. **A**◯ equal to **B**◯ less than **C**◯ greater than

▷ The volume V_f is ... V_i.
34. **A**◯ equal to **B**◯ less than **C**◯ greater than

▷ The entropy S_f is ... S_i.
35. **A**◯ equal to **B**◯ less than **C**◯ greater than



$p_f = p_i$ since it's isobaric

$V_f < V_i$ since it's compression

$T_f < T_i$ since we are crossing iso-therms toward the lower temps.

$U_f < U_i$ because $T_f < T_i$ and $U = \frac{f}{2} nRT$

$S_f < S_i$ since we are crossing adiabats toward the lower entropies.

3 pt A Stirling-engine is used in the heat-pump mode to heat a house. The engine maintains a temperature of 23.7 °C inside the house. The temperature of the Earth loop is 11.3 °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?

36. **A**◯ 6.28 **B**◯ 7.84 **C**◯ 9.81 **D**◯ 1.23×10^1
E◯ 1.53×10^1 **F**◯ 1.92×10^1 **G**◯ 2.39×10^1 **H**◯ 2.99×10^1

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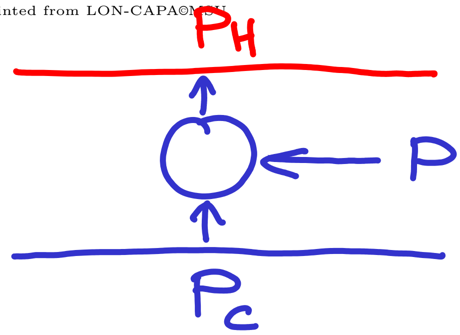
3 pt If the power of the electric motor driving the heat pump is 174 W, then what is the rate at which heat is delivered to the house?
(in W*)*

37. **A**◯ 4.48×10^2 **B**◯ 6.50×10^2 **C**◯ 9.42×10^2 **D**◯ 1.37×10^3
E◯ 1.98×10^3 **F**◯ 2.87×10^3 **G**◯ 4.17×10^3 **H**◯ 6.04×10^3



$T_H = 23.7°C = 296.7 K$

$P = 174 W$

$T_c = 11.3°C = 284.3 K$

$$K = \frac{P_H}{P} = \frac{P_H}{P_H - P_c} \overset{\text{Carnot}}{=} \frac{T_H}{T_H - T_c}$$

$$K = \frac{296.7}{12.4} = 23.9$$

$$K = \frac{P_H}{P} \Rightarrow P_H = K P = 23.9 \cdot 174 = 4163 W$$