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
- $\rho_{water} = 1000$ 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
- $c_{water} = 4.1868$ 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.

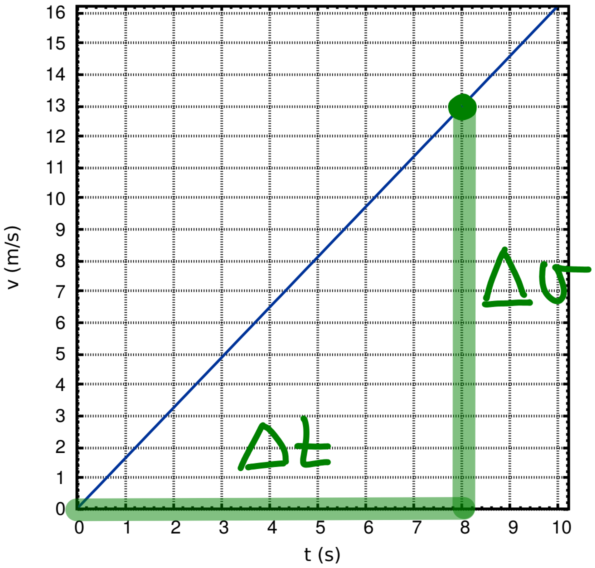
3 pt An apple, a brick and a hammer are all dropped from the second floor of a building at the same time. Which object(s) will hit the ground first?

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

All (compact and dense) objects fall together when they are released from the same height at the same time.

Galileo Galilei

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



acceleration:

$$a = \frac{\Delta v}{\Delta t} = \frac{13\,m/s}{8\,s} = $$
$$= 1.625\,m/s^2$$

$\boxed{3\ pt}$ 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 `m/s^2`*)*

3. **A**◯ 0.7805 **B**◯ 0.8820 **C**◯ 0.9966 **D**◯ 1.126
E◯ 1.273 **F**◯ 1.438 **G**◯ 1.625 **H**◯ 1.836

$\boxed{3\ pt}$ How much distance does the car cover between $t_1 = 2.05$ s and $t_2 = 4.99$ s?
(in `m`*)*

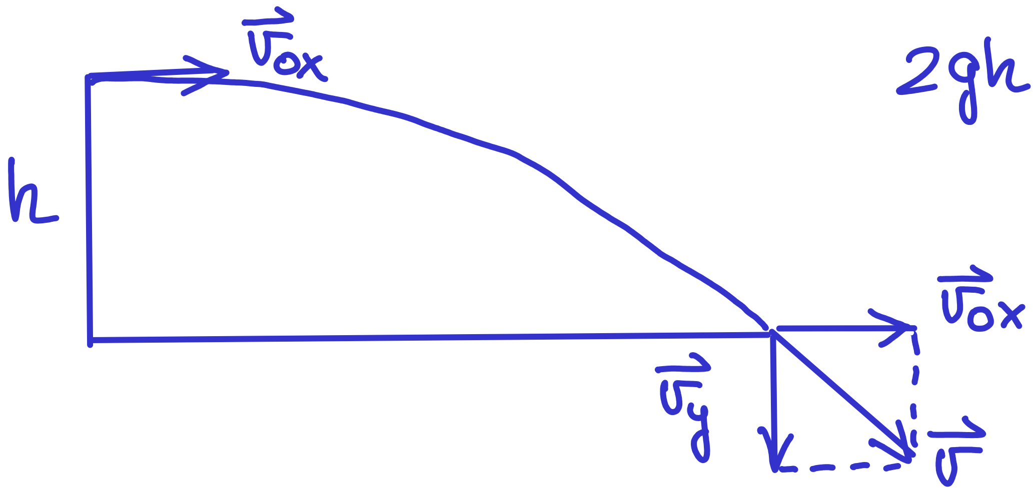
4. **A**◯ 4.041 **B**◯ 5.374 **C**◯ 7.148 **D**◯ 9.507
E◯ 12.64 **F**◯ 16.82 **G**◯ 22.37 **H**◯ 29.75

$$d = d_2 - d_1 = \frac{1}{2}at_2^2 - \frac{1}{2}at_1^2 =$$
$$= \frac{1}{2}a(t_2^2 - t_1^2) = \frac{1}{2}\cdot 1.625\cdot(4.99^2 - 2.05^2) =$$
$$= 16.82\,m$$

$\boxed{4\ pt}$ A baseball is projected horizontally with an initial speed of 8.49 m/s from a height of 1.64 m. What is the speed of the baseball when it hits the ground? (Neglect air friction.)
(in m/s*)*

5. **A**◯ 6.26 **B**◯ 7.08 **C**◯ 8.00 **D**◯ 9.04
E◯ 1.02×10^{1} **F**◯ 1.15×10^{1} **G**◯ 1.30×10^{1} **H**◯ 1.47×10^{1}

$$2gh = v_y^2$$



$$v^2 = v_{ox}^2 + v_y^2 = v_{ox}^2 + 2gh =$$

$$= 8.49^2 + 2 \cdot 9.81 \cdot 1.64 = 104.3\ m^2/s^2$$

$$v = \sqrt{104.3} = 10.2\ m/s$$

4 pt Two forces $\mathbf{F_1}$ = -9.90**i** + 3.10**j** and $\mathbf{F_2}$ = 7.50**i** + 6.40**j** are acting on an object with a mass of m = 6.10 kg. The forces are measured in newtons, **i** and **j** are the unit vectors. What is the magnitude of the object's acceleration? *(in* `m/s^2`*)*

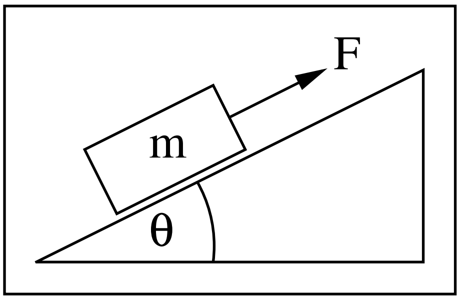
6. **A**◯ 8.57×10^{-1} **B**◯ 1.00 **C**◯ 1.17 **D**◯ 1.37
E◯ 1.61 **F**◯ 1.88 **G**◯ 2.20 **H**◯ 2.57

$$\vec{F}_1 = -9.9\hat{i} + 3.1\hat{j}$$
$$\vec{F}_2 = 7.5\hat{i} + 6.4\hat{j}$$
$$\vec{F}_{net} = -2.4\hat{i} + 9.5\hat{j}$$
$$F_{net} = |\vec{F}_{net}| = \sqrt{(-2.4)^2 + (9.5)^2} = 9.80\,\text{N}$$

Newton's 2nd law:

$$a = \frac{F_{net}}{m} = \frac{9.80}{6.10} = 1.61\,\text{m/s}^2$$

4 pt A force **F**, with a magnitude of 20.10 N, acts on an object with a mass of m = 1.34 kg parallel to the plane of the incline as shown in the figure.



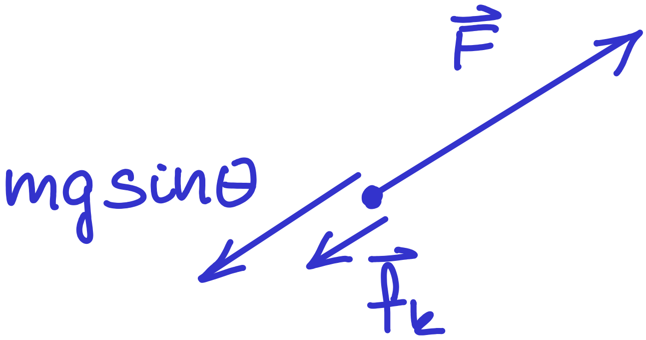
constant velocity $\Rightarrow$

$\Rightarrow a = 0 \Rightarrow F_{net} = 0$

$F_{net} = m \cdot a$

The angle of the incline is $\theta = 42.2°$. The object is observed to move at a constant velocity of 4.15 m/s up on the incline. Calculate the magnitude of the frictional force acting on the object.
(in N*)*

7. **A**◯ 9.97 **B**◯ 1.13×10^1 **C**◯ 1.27×10^1 **D**◯ 1.44×10^1
E◯ 1.63×10^1 **F**◯ 1.84×10^1 **G**◯ 2.08×10^1 **H**◯ 2.35×10^1



$mg\sin\theta + f_k = F$

$f_k = F - mg\sin\theta = 20.10 - 1.34 \cdot 9.81 \cdot \sin 42.2°$

$f_k = 11.3\,N$

$\boxed{\textit{3 pt}}$ A crane at a construction site lifts a concrete block with a mass of m = 486 kg from the ground to the top of a building with a height of h = 17.6 m. How much work did the motor of the crane do? (Assume zero energy loss in the lifting mechanism due to friction.)
(in J*)*

8. **A**◯ 3.99×10^4 **B**◯ 5.79×10^4 **C**◯ 8.39×10^4 **D**◯ 1.22×10^5
E◯ 1.76×10^5 **F**◯ 2.56×10^5 **G**◯ 3.71×10^5 **H**◯ 5.38×10^5

$\boxed{\textit{3 pt}}$ If the duration of the lift was 1.55 minutes, then what was the average power performed by the crane?
(in W*)*

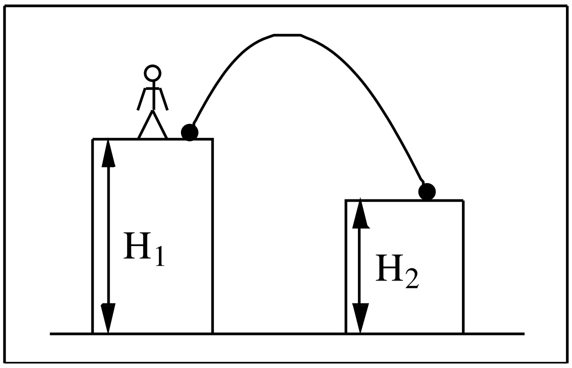
9. **A**◯ 1.23×10^2 **B**◯ 1.63×10^2 **C**◯ 2.17×10^2 **D**◯ 2.88×10^2
E◯ 3.84×10^2 **F**◯ 5.10×10^2 **G**◯ 6.78×10^2 **H**◯ 9.02×10^2

Work: $W = mg \cdot h = 486 \cdot 9.81 \cdot 17.6 =$

$= 83{,}910 \text{ J}$

Power: $P = \frac{W}{t} = \frac{83{,}910}{1.55 \cdot 60} = 902 \text{ W}$

4 pt A soccer ball is kicked from the top of one building with a height of $H_1 = 32.7$ m to another building with a height of $H_2 = 13.0$ m. (It is not a very smart idea to play soccer on the roof of tall buildings.)



Conservation of energy:

$$PE_1 + KE_1 = PE_2 + KE_2$$

The ball is kicked with a speed of $v_0 = 16.3$ m/s at an angle of $\theta = 76.9°$ with respect to the horizontal. The mass of a size 5 soccer ball is m = 450 g. What is the speed of the soccer ball, when it lands on the roof of the second bulding? The soccer ball is kicked without a spin. Neglect air resistance.
(in m/s*)*

10. **A** ◯ 1.16×10^1 **B** ◯ 1.36×10^1 **C** ◯ 1.59×10^1 **D** ◯ 1.87×10^1
E ◯ 2.18×10^1 **F** ◯ 2.55×10^1 **G** ◯ 2.99×10^1 **H** ◯ 3.50×10^1

$$mgH_1 + \frac{1}{2}mv_1^2 = mgH_2 + \frac{1}{2}mv_2^2$$

$$2g(H_1 - H_2) + v_1^2 = v_2^2$$

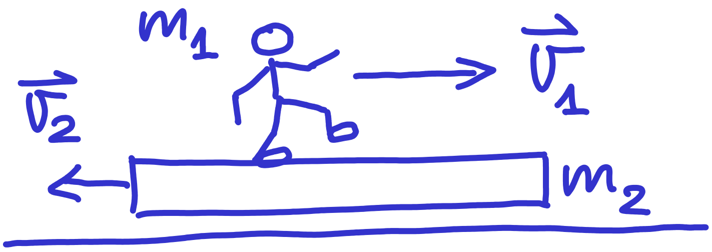
$$v_2 = \sqrt{2g(H_1 - H_2) + v_1^2} =$$

$$= \sqrt{2 \cdot 9.81 \cdot (32.7 - 13.0) + 16.3^2}$$

$$v_2 = 25.5 \text{ m/s}$$

$\boxed{4\ pt}$ A 75.3 kg wood board is resting on very smooth ice in the middle of a frozen lake. A 36.9 kg boy stands at one end of the board. He walks from one end of the board to the other end with a velocity of 1.47 m/s relative to the ice in the positive direction. What is the velocity of the board relative to the ice?
(in `m/s`*)*

11. **A**◯ -1.13 **B**◯ -0.994 **C**◯ -0.857 **D**◯ -0.720
E◯ 0.720 **F**◯ 0.857 **G**◯ 0.994 **H**◯ 1.13



Conservation of linear momentum:

$$0 = m_1 \cdot v_1 + m_2 v_2$$

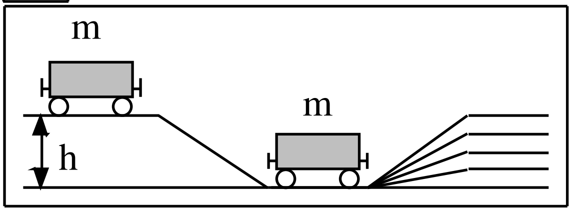
$$-m_1 v_1 = m_2 v_2$$

$$-\frac{m_1}{m_2} v_1 = v_2$$

$$v_2 = -\frac{36.9}{75.3} \cdot 1.47 = -0.72\,m/s$$

Negative sign means the board is moving to the left.

4 pt A railroad cart with mass **m** is at rest on the top of a hill with height **h**. (See figure.)



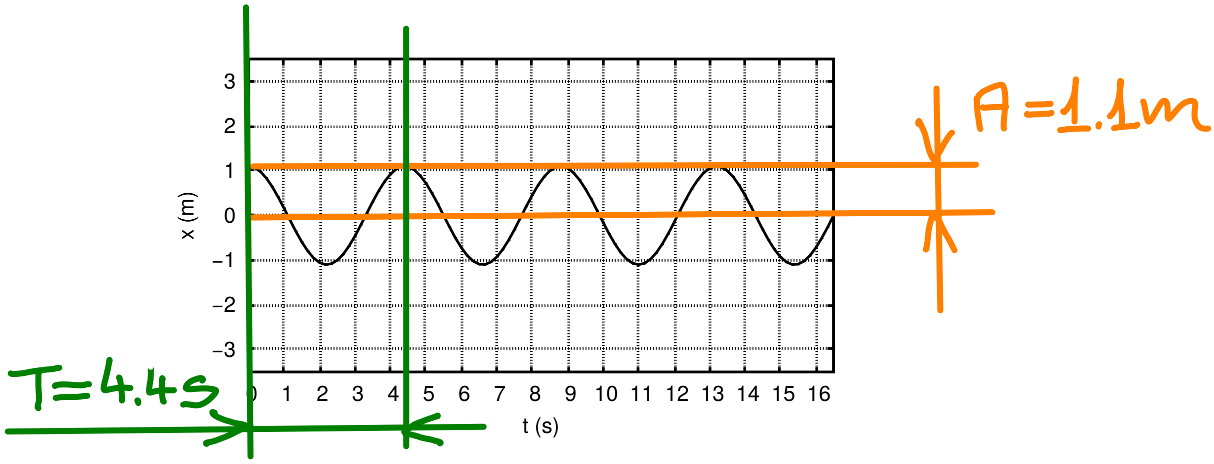
Then it starts to roll down. At the bottom it collides with an identical cart. The two carts lock together. How high can they reach together? (Neglect any losses due to friction.)

12. **A**◯ (1/4)**h**, one quarter of the original height.
B◯ Zero, they cannot climb any height.
C◯ **h**, the original height.
D◯ (3/4)**h**, three quarter of the original height.
E◯ (1/2)**h**, half of the original height.

Rolling down from height h gives you speed v. Inelactic collision with an identical object will cut your speed in to half: $\frac{v}{2}$. This $\frac{v}{2}$ speed will take you to height $\frac{h}{4}$ because kinetic energy is quadratic in speed and potential energy is directly proportional to height: $\frac{1}{2}mv^2 = mgh$

$$v^2 = 2gh$$

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

$\boxed{3\ pt}$ Using the graph determine the amplitude A of the oscillation.
(in m*)*

13. **A**◯ 2.00×10^{-1} **B**◯ 5.00×10^{-1} **C**◯ 1.10 **D**◯ 2.00
E◯ 2.60 **F**◯ 3.20 **G**◯ 3.50 **H**◯ 4.40

$\boxed{3\ pt}$ Determine the period T of the oscillation.
(in s*)*

14. **A**◯ 2.80 **B**◯ 4.00 **C**◯ 4.40 **D**◯ 4.80 **E**◯ 5.20 **F**◯ 6.40 **G**◯ 7.20 **H**◯ 7.60

$\boxed{3\ pt}$ An object is performing simple harmonic oscillation whose amplitude is 30.0 cm, and period is 3.35 s. Determine the maximum speed of the object.
(in `m/s`*)*

15. **A** ◯ 3.45×10^{-1} **B** ◯ 3.90×10^{-1} **C** ◯ 4.41×10^{-1} **D** ◯ 4.98×10^{-1}
E ◯ 5.63×10^{-1} **F** ◯ 6.36×10^{-1} **G** ◯ 7.18×10^{-1} **H** ◯ 8.12×10^{-1}

$\boxed{3\ pt}$ Determine the maximum acceleration of the object.
(in `m/s^2`*)*

16. **A** ◯ 6.75×10^{-1} **B** ◯ 8.44×10^{-1} **C** ◯ 1.06 **D** ◯ 1.32
E ◯ 1.65 **F** ◯ 2.06 **G** ◯ 2.58 **H** ◯ 3.22

Amplitude: $A = 30\ cm = 0.3\ m$

Period: $T = 3.35\ s$

Angular frequency: $\omega = \frac{2\pi}{T} = 1.876\ \frac{rad}{s}$

Max. speed: $v_{max} = A \cdot \omega = 0.563\ m/s$

Max. acceleration: $a_{max} = A \cdot \omega^2 =$

$= 1.06\ m/s^2$

4 pt Planet-X has a mass of 5.30×10^{24} kg and a radius of 3760 km. What is the Escape Speed *i.e.* the minimum speed required for a satellite in order to break free permanently from the planet?
(in `km/s`*)*

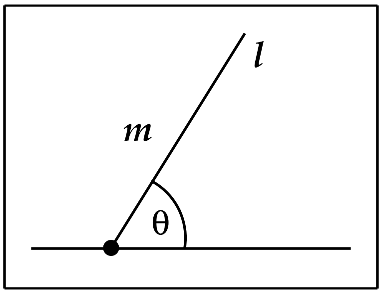
17. **A** ◯ 1.02 **B** ◯ 1.48 **C** ◯ 2.14 **D** ◯ 3.10
E ◯ 4.50 **F** ◯ 6.52 **G** ◯ 9.46 **H** ◯ 1.37×10^{1}

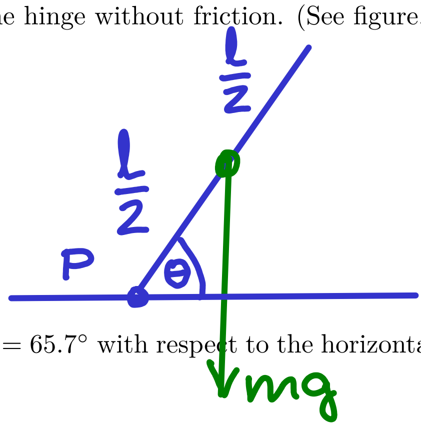
Escape Speed: $v_{II} = \sqrt{\frac{2GM}{R}}$

$$v_{II} = \sqrt{\frac{2 \cdot 6.67 \cdot 10^{-11} \cdot 5.3 \cdot 10^{24}}{3.76 \cdot 10^{6}}}$$

$$v_{II} = 13{,}713 \frac{m}{s} \approx 13.7 \frac{km}{s}$$

$\boxed{\textit{4 pt}}$ A uniform rod with a mass of $m = 1.72$ kg and a length of $l = 2.39$ m is attached to a horizontal surface with a hinge. The rod can rotate around the hinge without friction. (See figure.)





$$I_P = \frac{1}{3} m l^2$$

The rod is held at rest at an angle of $\theta = 65.7°$ with respect to the horizontal surface. What is the angular acceleration of the rod, when it is released?
(in `rad/s^2`*)*

18. **A**◯ 1.55 **B**◯ 1.76 **C**◯ 1.98 **D**◯ 2.24 **E**◯ 2.53 **F**◯ 2.86 **G**◯ 3.24 **H**◯ 3.66

Newton's 2nd law for rotations:

$$\tau = I_P \cdot \alpha$$

$$mg \frac{l}{2} \cdot \cos\theta = \frac{1}{3} m l^2 \cdot \alpha$$

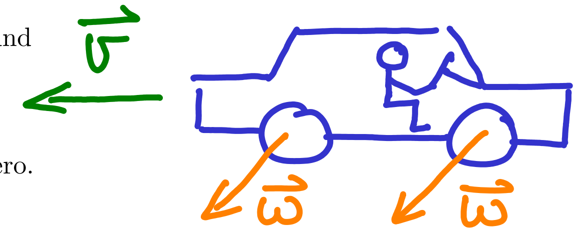
$$\frac{3}{2} \cdot \frac{g}{l} \cdot \cos\theta = \alpha$$

$$\alpha = \frac{3}{2} \cdot \frac{9.81}{2.39} \cdot \cos 65.7°$$

$$\alpha = 2.53 \text{ rad/s}^2$$

$\boxed{\textit{2 pt}}$ You are going to back out of a driveway. You put your car in reverse and you start driving backwards. The driveway is straight and horizontal. What is the direction of the velocity vector of your car?

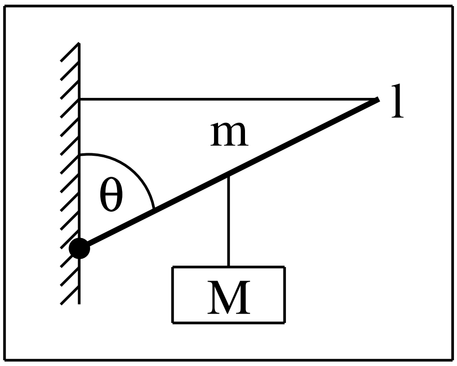
19.A◯ forward
B◯ down to the ground
C◯ to your left
D◯ to your right
E◯ backward
F◯ The velocity is zero.
G◯ up to the sky

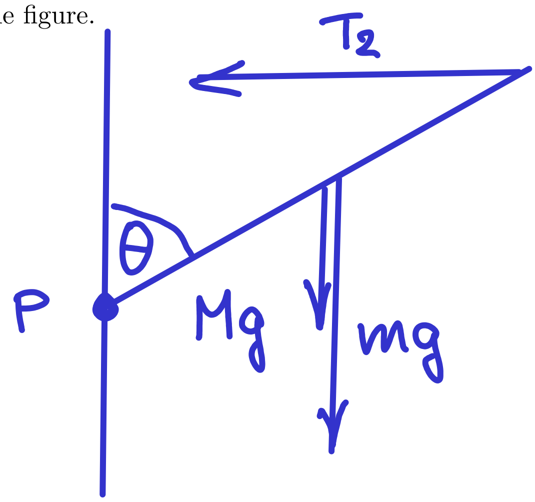


$\boxed{\textit{2 pt}}$ What is the direction of the angular velocity vector of your wheels?

20.A◯ up to the sky
B◯ backward
C◯ down to the ground
D◯ to your right
E◯ forward
F◯ to your left
G◯ The angular velocity is zero.

A crate with a mass of M = 67.5 kg is suspended by a rope from the midpoint of a uniform boom. The boom has a mass of m = 122 kg and a length of l = 9.25 m. The end of the boom is supported by another rope which is horizontal and is attached to the wall as shown in the figure.





3 pt The boom makes an angle of $\theta = 57.4°$ with the vertical wall. Calculate the tension in the vertical rope. *(in N)*

21. **A**◯ 5.30×10^2 **B**◯ 6.62×10^2 **C**◯ 8.28×10^2 **D**◯ 1.03×10^3
E◯ 1.29×10^3 **F**◯ 1.62×10^3 **G**◯ 2.02×10^3 **H**◯ 2.53×10^3

$T_1 = Mg =$
$= 67.5 \cdot 9.81 = 662\,N$

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

22. **A**◯ 6.98×10^2 **B**◯ 7.89×10^2 **C**◯ 8.91×10^2 **D**◯ 1.01×10^3
E◯ 1.14×10^3 **F**◯ 1.29×10^3 **G**◯ 1.45×10^3 **H**◯ 1.64×10^3

Torque balance with respect to P:

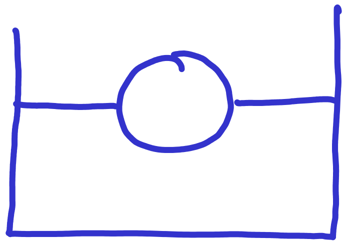
$$Mg\frac{l}{2}\cdot\sin\theta + mg\frac{l}{2}\cdot\sin\theta = T_2\, l\cos\theta$$

$$\frac{1}{2}(M+m)g\tan\theta = T_2$$

$$T_2 = \frac{1}{2}(67.5+122)\cdot 9.81\cdot\tan 57.4°$$

$$T_2 = 1453\,N$$

$\boxed{6\ pt}$ A solid, homogeneous sphere with a mass of m_0, a radius of r_0 and a density of ρ_0 is placed in a container of water. Initially the sphere floats and the water level is marked on the side of the container. What happens to the water level, when the original sphere is replaced with a new sphere which has different physical parameters? Notation: r means the water level rises in the container, f means falls, s means stays the same.



▷ The new sphere has a density of $\rho = \rho_0$ and a radius of $r < r_0$.
23. **A**◯ r **B**◯ f **C**◯ s

▷ The new sphere has a radius of $r > r_0$ and a mass of $m = m_0$.
24. **A**◯ r **B**◯ f **C**◯ s

▷ The new sphere has a mass of $m > m_0$ and a density of $\rho = \rho_0$.
25. **A**◯ r **B**◯ f **C**◯ s

Density : $\rho = \frac{m}{V}$

Objects floating on the surface displace water equivalent to their mass or weight.

Objects sinking to the bottom displace water equivalent to their volume.

$\boxed{\textit{4 pt}}$ A rock band uses a wall built out of 39 identical speakers. If one single speaker can produce a sound level of 93.5 dB in the front row area, then what is the sound level produced by the whole wall?
(in dB*)*

26. **A**◯ 70.0 **B**◯ 87.5 **C**◯ 109.4 **D**◯ 136.8
E◯ 171.0 **F**◯ 213.7 **G**◯ 267.1 **H**◯ 333.9

Intensity from one speaker: I_1

Intensity from 39 speakers: $I_{39} = 39 \cdot I_1$

Sound level of one speaker:

$$S_1 = 10 \cdot \log(I_1/I_0)$$

Sound level of 39 speakers:

$$S_{39} = 10 \cdot \log(I_{39}/I_0) =$$

$$= 10 \cdot \log(39 I_1/I_0) =$$

$$= 10 \cdot \log(39) + \underbrace{10 \cdot \log(I_1/I_0)}_{S_1} =$$

$$= 15.9 + 93.5 = 109.4\,\text{dB}$$

$\boxed{4\ pt}$ An organ pipe is 1.70 m long and it is open at one end and closed at the other end. What are the frequencies of the lowest three harmonics produced by this pipe? The speed of sound is 340 m/s. Only one answer is correct.

27.A◯ 50 Hz, 100 Hz, 150 Hz
B◯ 100 Hz, 200 Hz, 300 Hz
C◯ 200 Hz, 300 Hz, 400 Hz
D◯ 50 Hz, 100 Hz, 200 Hz
E◯ 100 Hz, 300 Hz, 500 Hz
F◯ 50 Hz, 150 Hz, 250 Hz
G◯ 200 Hz, 400 Hz, 600 Hz
H◯ 200 Hz, 600 Hz, 1000 Hz

An open-closed pipe holds $\frac{1}{4}, \frac{3}{4}, \frac{5}{4}, \frac{7}{4} \ldots$ waves with $f_1, 3f_1, 5f_1, 7f_1$ frequencies.

$$L = \frac{1}{4}\lambda_1 \Rightarrow 4L = \lambda_1$$

$$c = \lambda f \Rightarrow f_1 = \frac{c}{\lambda_1} = \frac{c}{4L} = \frac{340}{4 \cdot 1.70} = 50\text{ Hz}$$

Frequencies: 50Hz, 150Hz, 250Hz, ...

$\boxed{\textit{4 pt}}$ An aluminium object with a mass of 2.79 kg and at a temperature of 22.8 °C comes to thermal contact with a 7.26 kg copper object which is initially at a temperature of 87.1 °C. What is going to be the equilibrum temperature of the two objects? Neglect heat transfer between the objects and the environment. The specific heats are: c_{Al} = 900 J/kg°C and c_{Cu} = 387 J/kg°C.
(in `degC`*)*

28. **A**◯ 36.3 **B**◯ 45.4 **C**◯ 56.8 **D**◯ 70.9
E◯ 88.7 **F**◯ 110.8 **G**◯ 138.6 **H**◯ 173.2

Conservation of energy: $Q_1 + Q_2 = 0$

$$c_1 \cdot m_1 \cdot (T_f - T_1) + c_2 \cdot m_2 \cdot (T_f - T_2) = 0$$

$$T_f = \frac{c_1 \cdot m_1 \cdot T_1 + c_2 \cdot m_2 \cdot T_2}{c_1 \cdot m_1 + c_2 \cdot m_2}$$

$$T_f = \frac{900 \cdot 2.79 \cdot 22.8 + 387 \cdot 7.26 \cdot 87.1}{900 \cdot 2.79 + 387 \cdot 7.26}$$

$$T_f = 56.8\,°C$$

$\boxed{4\ pt}$ 5.10 liters of Nitrogen gas at 23.0°C temperature and 1.60 atm pressure contains how many moles?

29. **A**◯ 0.143 **B**◯ 0.161 **C**◯ 0.182 **D**◯ 0.206
E◯ 0.233 **F**◯ 0.263 **G**◯ 0.297 **H**◯ 0.336

Ideal gas law: $pV = nRT \Rightarrow$

$$\Rightarrow n = \frac{pV}{RT} = \frac{1.6 \cdot 101{,}300 \cdot 0.0051}{8.31 \cdot 296}$$

$$n = 0.336 \text{ mol}$$

$\boxed{5\ pt}$ Constant amount of ideal gas is kept inside a cylinder by a piston. Then the piston compresses the gas **adiabatically**. Compare the initial (i) and the final (f) physical quantities of the gas to each other.

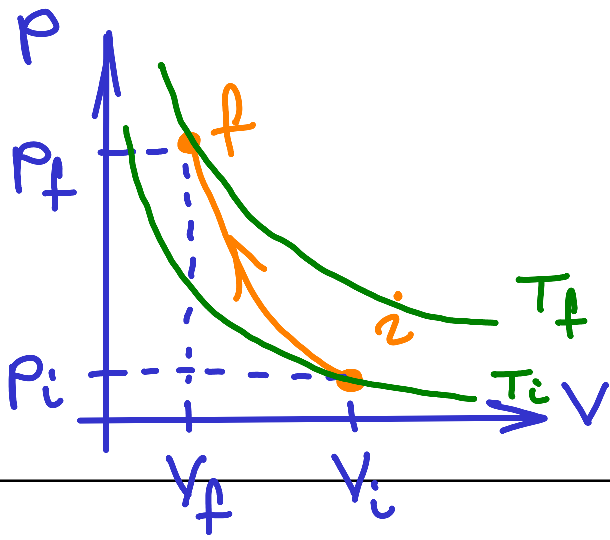
▷ The volume V_f is ... V_i.
30. A◯ equal to **B**◯ less than **C**◯ greater than

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

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



→ $V_f < V_i$ b/c it is a compression

→ $P_f > P_i$ b/c $P_f V_f^{\gamma} = P_i V_i^{\gamma}$

→ $T_f > T_i$ b/c we are crossing isotherms, and adiabats are steeper than isotherms.

→ $U_f > U_i$ b/c $T_f > T_i$ and internal energy depends only on temperature.

→ $S_f = S_i$ b/c no heat is transferred in an adiabatic process.

$\boxed{3\ pt}$ An ideal heat engine has an efficiency of 15.2 percent. It operates between two heat reservoirs differing in temperature by 66.7 C°. What is the temperature of the hot reservoir?
(in K*)*

35. **A**◯ 2.00×10^2 **B**◯ 2.34×10^2 **C**◯ 2.74×10^2 **D**◯ 3.21×10^2
E◯ 3.75×10^2 **F**◯ 4.39×10^2 **G**◯ 5.13×10^2 **H**◯ 6.01×10^2

efficiency: $\eta = 15.2\% = 0.152$

$\Delta T = T_H - T_c = 66.7\,^\circ C = 66.7\ K$

Carnot efficiency:

$$\eta = \frac{T_H - T_c}{T_H} = \frac{\Delta T}{T_H} \Rightarrow T_H = \frac{\Delta T}{\eta} =$$

$$= \frac{66.7\ K}{0.152} = 439\ K$$