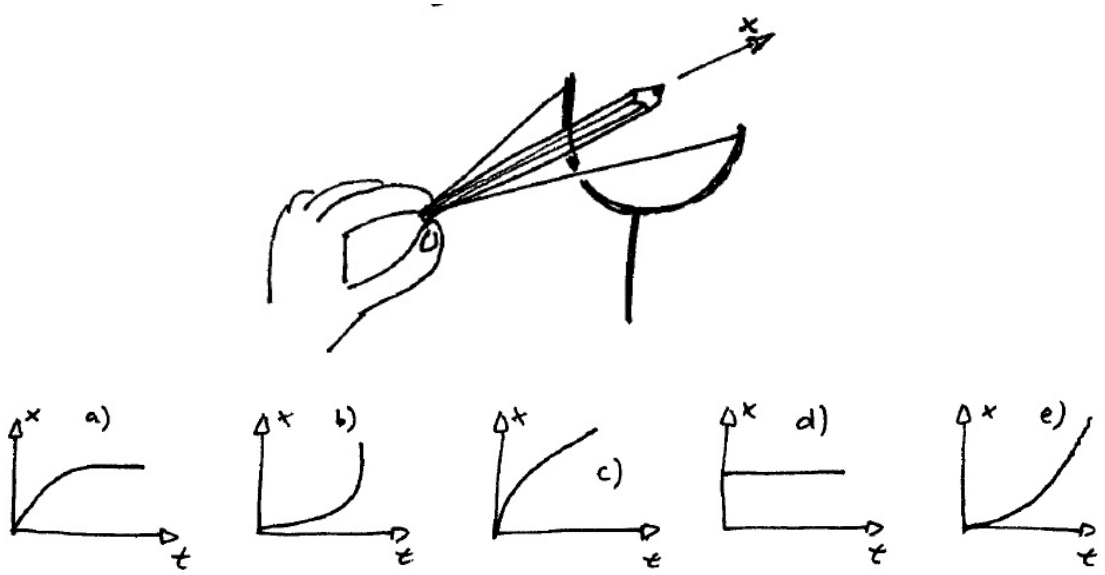
1. Town A is at a distance of $916\ \mathrm{km}$ from town B. Peter leaves town A for town B by train at 8h00 in the morning, speed $132\ \mathrm{km/h}$. Emma leaves town B for town A by train at 9h00 in the morning, speed $113\ \mathrm{km/h}$. At what time will the two trains meet?
   a. 11h12
   b. 11h40
   c. 12h12
   d. 12h40

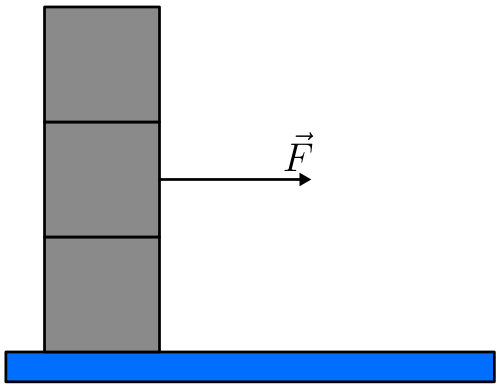
2. A schoolboy is having fun shooting pencils using a rubber band stretched over a fork. Which of the curves below best describes the motion of the pencil along the axis x while in contact with the rubber band?



   a. a)
   b. b)
   c. c)
   d. d)
   e. e)

3. The aerodynamics of a Formula 1 car are very important. Assume a car with a very powerful motor and very low fuel consumption needs to have its aerodynamics tuned to navigate tight bends at high speed. What approach would you choose?
   a. Reduce drag forces as much as possible.
   b. Reduce downward force to reduce rolling friction for the tyres.
   c. Increase downward force at the expense of an increased drag force.
   d. Find a balance between downward force and drag force.
   e. None of the above will influence the performance of the car.

4. 3 blocks of equal mass m are stacked on top of each other and stand on a **frictionless** surface. The coefficient of friction between the blocks is μ. We apply a force to the middle of the second block.



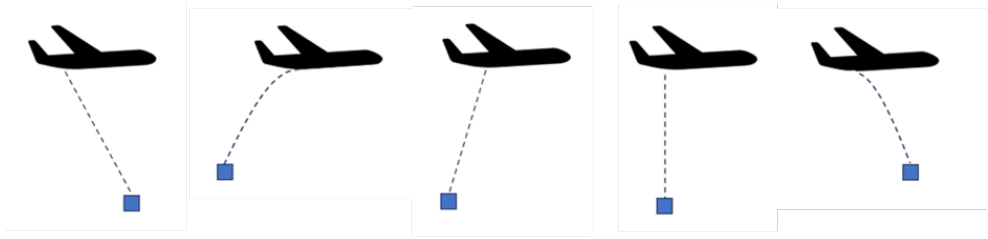
Which one of the following statements is true?

a. If we pull forward slowly the tower will topple over.
b. There is a minimal force which would allow us to pull the bottom 2 blocks from the tower.
c. There is a minimal force which would allow us to pull the top 2 blocks from the tower.
d. There is no way to extract the middle block from the tower.
e. None of the above statements are true.

5. A delivery service puts a package on a $2.5\ \mathrm{m}$ high truck without strapping the package down. The truck accelerates slowly up to a speed of $20\ \mathrm{m/s}$. The truck then breaks with a deceleration of $10\ \mathrm{m/s^2}$. The package frictionlessly flies horizontaly off the truck, flies through the air without any resistance, lands on the road and comes to a stop where it lands. Select the correct assertion.

a. The truck stops in front of the package.
b. The package gets overrun by the truck.
c. The package hits the trucks windshield.
d. The truck exactly stops on the package.
e. None of the above.

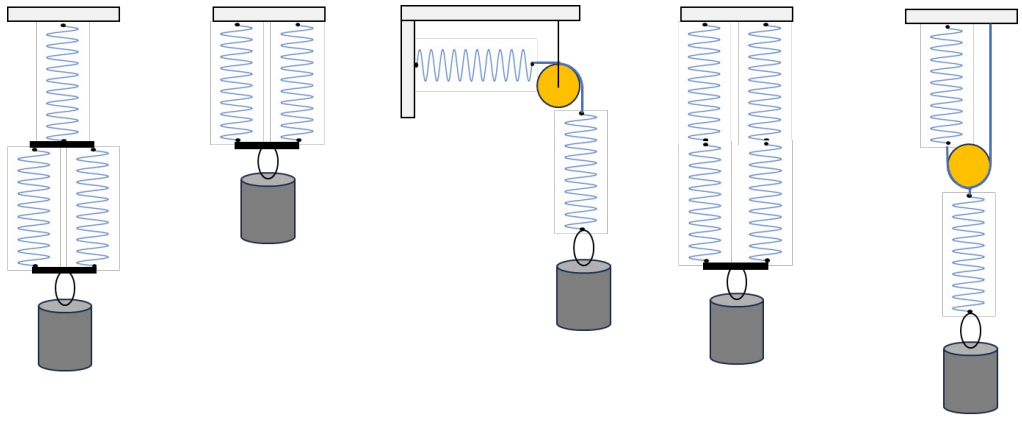
6. A cargo is dropped from a flying aeroplane which is moving uniformly and in a straight line to the right. Which trajectory in the terrestrial reference frame will the cargo follow, assuming that air resistance is neglected?



a) b) c) d) e)

a. a)
b. b)
c. c)
d. d)
e. e)

7. The following pictures show 5 different devices with identical mechanical springs, each carrying a load with the same mass (grey). Which of the five devices has the same total spring constant as a single spring?
(For example: mass $1\ \mathrm{kg}$, spring constant $60\ \mathrm{N/m}$)



a) b) c) d) e)

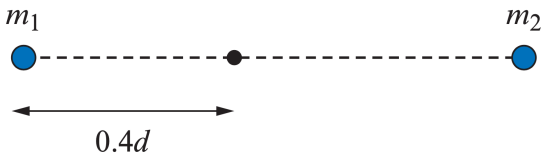
a. a)
b. b)
c. c)
d. d)
e. e)

8. A new pair of low mass planets orbiting a massive central star has been detected by a group of astronomers. Select the correct assertion:
   a. The mass of each planet may be calculated from its orbital period and its semi-major axis.
   b. The ratio of the orbital periods is only determined by the mass of the central star.
   c. The mass of the central star may be calculated from the orbital period of the planets and their semi-major axis.
   d. If the 3 bodies are initially aligned, they have to come into alignment at a later date again.
   e. None of the above.

9. In the future a spacecraft carrying humans to another planet may be spinning to simulate gravity. Calculate the necessary angular velocity of a spacecraft with an outer diameter of $10\ \mathrm{m}$ to simulate earth's gravity of $g = 10\ \mathrm{m/s^2}$.
   a. $\omega \approx 0.71\ \mathrm{rad/s}$
   b. $\omega \approx 1.0\ \mathrm{rad/s}$
   c. $\boldsymbol{\omega \approx 1.4\ \mathrm{rad/s}}$
   d. $\omega \approx 2.0\ \mathrm{rad/s}$
   e. None of the above.

10. A beam of length L is fixed on one end. A downward force F is applied to the free end of the beam, extending the beam downward by a distance x. The extension x is linear in F and is inversely proportional to the cross-section moment I, which has units $\mathrm{m^4}$. The extension is also dependent on Young's modulus E, which has units $\mathrm{N/m^2}$. Then x depends on L according to
    a. $x \sim \sqrt{L}$
    b. $x \sim L$
    c. $x \sim L^2$
    d. $\boldsymbol{x \sim L^3}$
    e. $x \sim L^4$

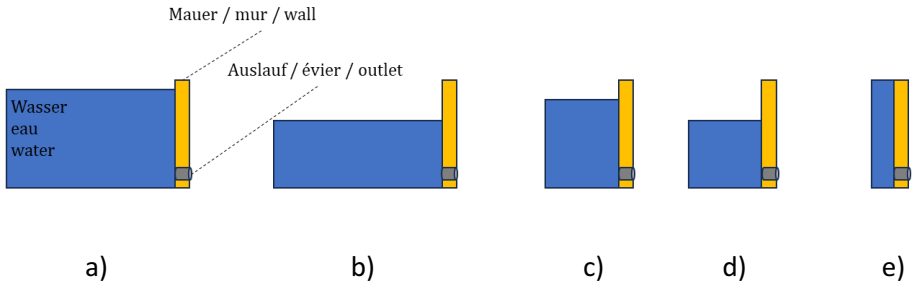
11. Two celestial bodies of masses m_1 and m_2 are separated by a distance d.



The resulting gravitational field cancels out at a point on the segment connecting the two masses at a distance of $0.4d$ from m_1. What is the ratio $\frac{m_1}{m_2}$?

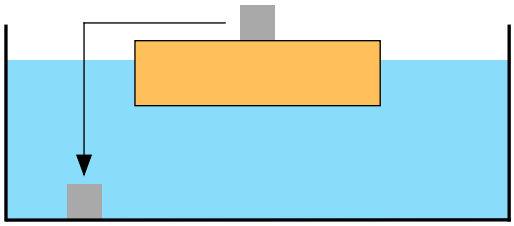
a. $\frac{2}{3}$
b. $\mathbf{\frac{4}{9}}$
c. $\frac{2}{5}$
d. $\frac{3}{5}$
e. $\frac{1}{3}$

12. The following pictures show five identical dams, each of which holds a different quantity of water. There is an outlet at the bottom of the wall to get rid of excess water. All outlets are opened at the same time. Which wall would release the most water at the beginning when the outlet is opened?



a. a)
b. b)
c. c)
d. d)
e. e)

13. A wooden board floats on the water in an aquarium. A metal cube rests on the board. The cube is now removed and placed at the bottom of the aquarium.



Compare the water level in the aquarium before and after moving the cube. Which of the following statements is correct?

a. The water level rises in all cases.
b. The water level falls in all cases.
c. The water level remains constant in all cases.
d. The direction of the variation in water level depends on the metal.

14. A liquid is flowing in a pipe with diameter d with a velocity v. Assume that the liquid is incompressible, i.e., its density remains constant. If the pipe gradually becomes thinner, and reaches a diameter $d/2$ at the end, which statement is true for the velocity v_F at the end of the pipe?

a. $v_F = v$
b. $v_F = v/2$
c. $v_F = 2v$
d. $\boldsymbol{v_F = 4v}$

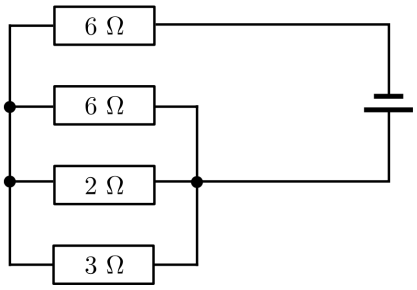
15. A bottle contains $1\ \mathrm{L}$ of water with a specific heat of $c = 4\ \mathrm{kJ/(kg\ K)}$ at a temperature of $20\ °\mathrm{C}$. A wire with a resistance of $10\ \Omega$ is inserted into the water and a voltage of $100\ \mathrm{V}$ is applied. What is the temperature of the water 2 minutes after switching on the current?

a. $95\ °\mathrm{C}$
b. $70\ °\mathrm{C}$
c. $\boldsymbol{50\ °\mathrm{C}}$
d. $20\ °\mathrm{C}$

16. On a summer day, Anne decides to go for a bike ride. Before setting off, she checked the tyre pressure and found that there was only $2\ \mathrm{bar}$ (i.e. an overpressure of $1\ \mathrm{bar}$) in the front tyre instead of the optimum value $4\ \mathrm{bar}$. She uses a simple hand pump to inflate the tyre to the optimum pressure. The pump draws in ambient air at $1\ \mathrm{bar}$ and injects it fully into the tyre at ambient temperature. How many times must it pump? The volume of the tyre is $2800\ \mathrm{cm}^3$ and the pump has a volume of $700\ \mathrm{cm}^3$.

a. 2
b. 4
c. 6
d. 8
e. 10

17. In the following circuit, we know that a current of $3\ \mathrm{A}$ flows through the resistor of $2\ \Omega$. What is the voltage supplied by the voltage source?



a. $12\ \mathrm{V}$
b. $21\ \mathrm{V}$
c. $30\ \mathrm{V}$
d. $\mathbf{42\ V}$
e. $51\ \mathrm{V}$

18. A constant voltage of $10\ \mathrm{V}$ is applied to the terminals of a motor which then lifts a mass of $1\ \mathrm{kg}$ with a speed of $v = 2\ \mathrm{m/s}$. Which of the following statements about the current flowing through the motor cannot be true?
a. It is greater than $1.5\ \mathrm{A}$.
b. With a current of $10\ \mathrm{A}$ the motor efficiency would be rather poor.
c. It is $\mathbf{1\ A}$ exactly.
d. With a current of $2.2\ \mathrm{A}$ the motor efficiency would be quite good.
e. It is greater than $0.5\ \mathrm{A}$.

19. In a block-spring system, the system is released at the maximum position at $t = 0$. At $t_1 = 0.2\ \mathrm{s}$ the block position is $x_1 = 0.1\ \mathrm{m}$ and at $t_2 = 0.8\ \mathrm{s}$ the block is at $x_2 = -0.1\ \mathrm{m}$. What is the amplitude of the oscillations?
a. $7.80\ \mathrm{cm}$
b. $\mathbf{12.4\ cm}$
c. $15.1\ \mathrm{cm}$
d. $18.7\ \mathrm{cm}$
e. $20.4\ \mathrm{cm}$

20. A pendulum with natural frequency f_0 oscillates inside a box. A person picks up the box and gently shakes it vertically with frequency f and a fixed amplitude for a fixed time. To maximize the final amplitude of the pendulum, f should satisfy
a. $\boldsymbol{f = 2f_0}$
b. $f = \sqrt{2} f_0$
c. $f = f_0$
d. $f = \frac{1}{2} f_0$
e. there will be no significant effect on the pendulum amplitude for any value of f.