Question$^{(1p)}$ 1. Guess which physicist of the following sequence is the odd one out.

(A) Galileo Galilei
(B) Henry Cavendish
(C) Michael Faraday
(D) Johannes Kepler
(E) Isaac Newton

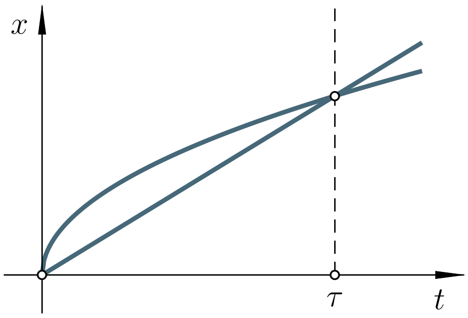
Question$^{(1p)}$ 2. The absolute zero of temperature is nearly equal to

(A) $+273.15^\circ$ C.
(B) $+273.15$ K.
(C) $|0|^\circ$ C.
(D) -273.15° C.
(E) -273.15 K.

Question$^{(1p)}$ 3. An object goes from one point in space to another. After it arrives at its destination, the magnitude of the displacement is

(A) either greater than or equal to the distance travelled.
(B) always greater than the distance travelled.
(C) always equal to the distance travelled.
(D) either smaller than or equal to the distance travelled.
(E) always smaller than the distance travelled.

Question$^{(1p)}$ 4. Displacement versus time graph, $x(t)$: straight line and parabolic curve, is for two ships on parallel courses. Select the answer that is certainly correct.

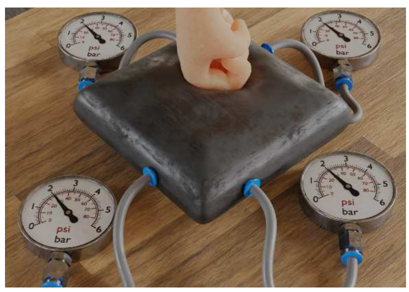


(A) Both ships have the same velocity at some instant before τ.
(B) At time τ, both ships have the same velocity.
(C) At time τ, both ships have the same acceleration.
(D) Both ships speed up the whole time.
(E) At some instant, both ships have the same acceleration.

Question$^{(1p)}$ 5. What physical unit named after a German physicist opposes when one physical unit named after an Italian physicist generates one physical unit named after a French physicist to flow?

(A) 1 A
(B) 1 V
(C) 1 Ω
(D) 1 Hz
(E) 1 W

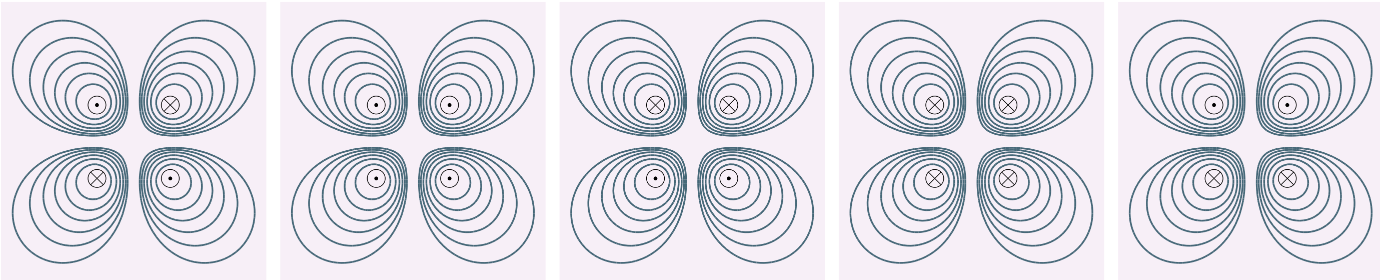
Question$^{(1p)}$ 6. In the following experiment, a rubber cushion is filled with water. Tubes are attached to different points of the cushion. At the other end of the tubes, there are pressure gauges. Now one squeezes the cushion at any place. One will notice that not only does the pressure rise near the contact point, but all the pressure gauges display equally. What physical law governs this phenomenon?



(A) Pascal's law
(B) Mass conservation law
(C) Torricelli's law
(D) Archimedes' law
(E) Law of horror vacui

Question(1p) **7.** The figures show cross sections of four long parallel straight wires in vacuum carrying equal electric currents, directly into (⊗) or out of the page (⊙). The wires are arranged at the corners of the square. The configuration of their magnetic induction lines surrounding them is also visualized. Find the correct arrangement of the current senses.

(A) (B) (C) (D) (E)

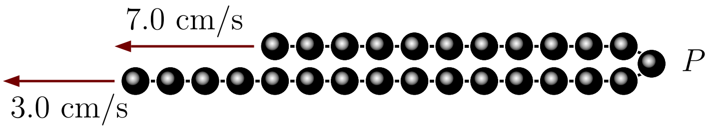


Question(1p) **8.** Let's say you perceive an upright magnified image of your face when you look into a magnifying cosmetic mirror. The image is then located

(A) only in your mind because it is a virtual image.
(B) behind the mirror's surface.
(C) only in your mind because it is a real image.
(D) in front of the mirror's surface.
(E) on the mirror's surface.

Question(2p) **9.** One end of an inextensible steel-ball chain is being pulled to the left at a uniform speed of $7.0\ \mathrm{cm/s}$, while the other is being pulled likewise at a uniform speed of $3.0\ \mathrm{cm/s}$, as shown. The chain lies on a flat frictionless table. Compute the speed acquired by the contra-flexure point P and determine its direction (right/left). The chain motion in its entirety should be regarded as unidimensional.

(A) $2.0\ \mathrm{cm/s}$ to the right.
(B) $5.0\ \mathrm{cm/s}$ to the right.
(C) $0.0\ \mathrm{cm/s}$, i.e. the point remains motionless.
(D) $5.0\ \mathrm{cm/s}$ to the left.
(E) $2.0\ \mathrm{cm/s}$ to the left.



Question(2p) **10.** You may have already seen a photograph of a beautiful nature scene captured by a photographer who set up the shot with a calm body of smooth lake water in the foreground. The non-rippling water provides for the specular reflection of light from the object, let's say a mountain. The light reflecting off the water undergoes specular reflection so the incident rays remain in a concentrated bundle instead of diffusing. The reflected rays are thus able to travel together with the direct ones to the lens of the camera and produce an image, an exact replica of the object, which is strong enough to be perceived in the photograph. An example of such a photograph is shown below, and the best spot on Earth seems to be Zermatt in Switzerland to provide the perfect reflection of the mighty Matterhorn taken by a camera from a certain height above the lake. Single out the statement that is totally alien to the common sense of optics.

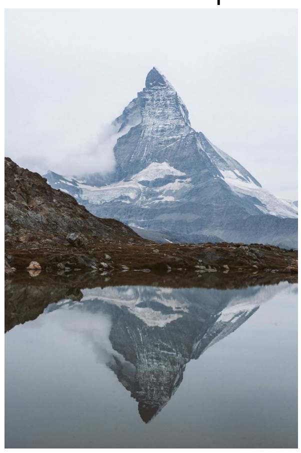
(A) Light from the mountain reaches the camera lens directly and/or it takes a longer path in which it reflects off the water before travelling to the lens.

(B) In the sense of Earth's gravity direction, it is unreliable by the randomly rotated photo to describe to an extraterrestrial alien what is *up* versus *down*.

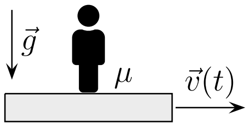
(C) As the reflected image of the mountain appears to be under the water level, our brain interprets it as being at a greater distance than the actual object.

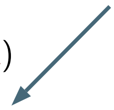
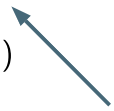
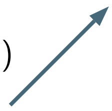
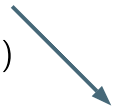
(D) The mirror image in the lake is only apparently smaller than the original, that is simply an illusion caused by the way our brain processes the visual information.

(E) To discriminate the reflected image size from its apparently greater original, the height at which the photo is taken above the lake plays a pivotal role.



Question$^{(2p)}$ 11. A person is standing upright on a horizontal platform which moves rectilinear to the right in the direction of instantaneous velocity vector $\vec{v}(t)$, as shown. While the person remains motionless relative to it, the platform is uniformly decelerating to a stop at a modulus of nearly $9.81\ \mathrm{m/s^2}$. The friction coefficient between the platform and the person has a huge value ($\mu \to \infty$). Which of the following vectors most faithfully depicts the vector of the resultant reaction force $\vec{R}$ with which the platform acts on the person during the motion?



(A)  (B)  (C)  (D)  (E) 

Question$^{(2p)}$ 12. Given below is a charged planar conductor at electrostatic equilibrium. Points A, B, and D are located on the edges of the conductor, whereas point C is located inside it. Rank the intensity of the electric field at points A, B, C, and D from strongest to weakest.

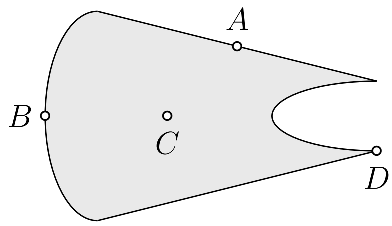
(A) $E_C > E_B > E_A > E_D$

(B) $E_D > E_C > E_A > E_B$

(C) $E_A > E_B > E_D > E_C$

(D) $E_D > E_A > E_B > E_C$

(E) $E_D > E_B > E_A > E_C$



Question$^{(2p)}$ 13. A point-like mass is located off-centre within the interior of a thin uniform massive ring, as shown below. If the entire system is situated in an external-gravity free space, then the ring-caused gravity force acting on the point-like mass is

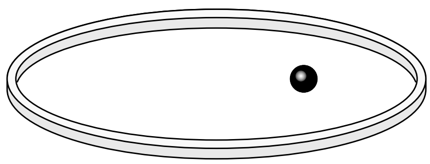
(A) directed leftward.

(B) directed rightward.

(C) zero inside the ring.

(D) directed upward.

(E) directed downward.



Question$^{(2p)}$ 14. When a non-magnetic steel ball is inserted inside an electrically resistive copper pipe as shown, it takes only twenty milliseconds for the ball to come out under gravity force. But when a spherical permanent magnet of both the same size and mass density as the ball is inserted, it takes as long as four seconds for the magnet to come out under gravity force. Pay attention that copper is not attracted towards magnets and may get heated. If one gets interested in understanding the underlying mechanisms of how this happens in its entirety, which one among the listed laws below would certainly not be of any use? The influence of the surrounding air can be neglected, while neither has the ball nor the magnet been in mechanical contact with the copper wall during their falls.

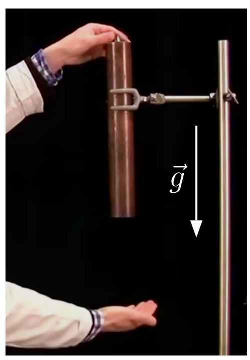
(A) Stokes' law

(B) Ohm's law

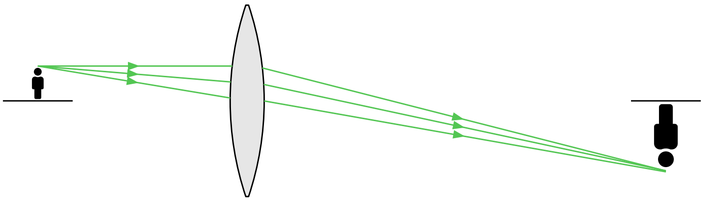
(C) Lenz's law

(D) Faraday's law of induction

(E) Joule-Lenz law



Question$^{(2p)}$ 15. A thin converging lens of focal length f forms an image of an object, as shown. The object is placed to your left at distance s from the lens. In this situation



(A) $s < f$.

(B) $s = f$.

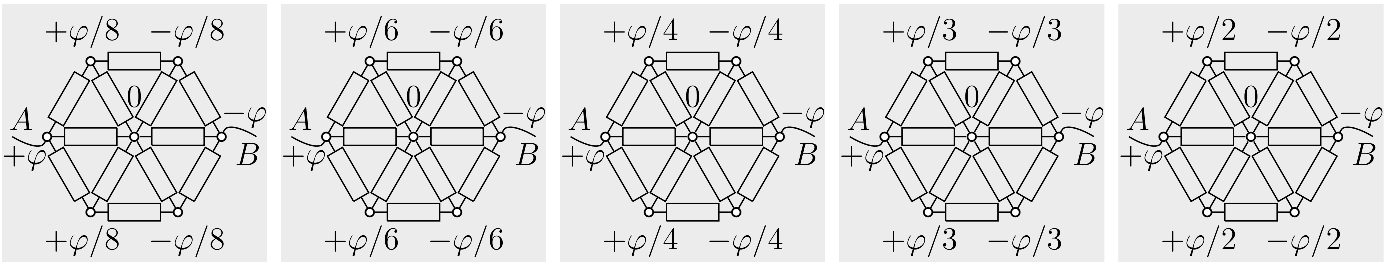
(C) $f < s < 2f$.

(D) $s = 2f$.

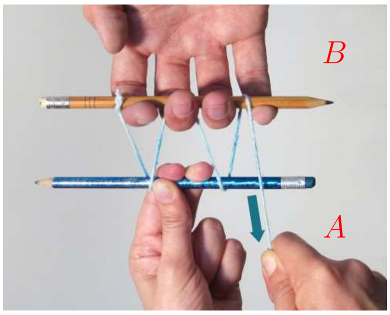
(E) $s > 2f$.

Question$^{(2p)}$ 16. The hob has 12 identical resistance wires, which are connected as shown (regular hexagon). What is the correct distribution of the electric potentials of the five nodes of the hotplate when voltage is applied across nodes A and B such that their electric potentials are $+\varphi > 0$ and $-\varphi < 0$, respectively?

(A) (B) (C) (D) (E)



Question$^{(3p)}$ 17. Two students, A and B, firmly knot a light inextensible shoelace to one pencil (A) to wrap it around the other (B), as shown. While student A gently moves his pencil, other one B holds his pencil still. Student A slowly pulls the open end of the shoelace with his right hand, introducing 0.4 J of his mechanical work. At the same time, with his left hand, this student parallelly displaces his pencil to the motionless one (B) by 10 mm. If the friction is negligible, then the tension force along the shoelace amounts



(A) 0.1 N.

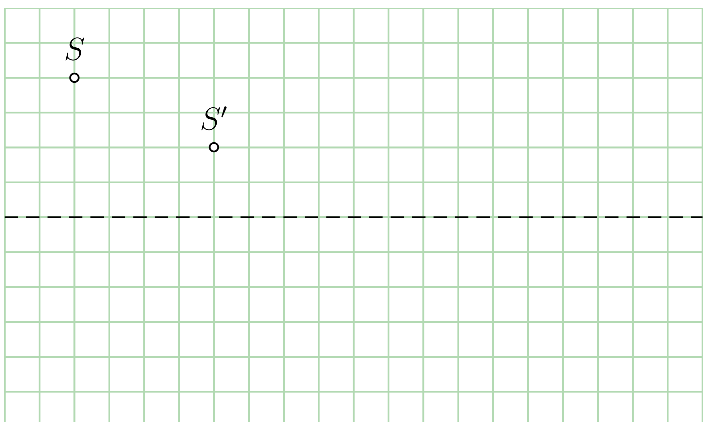
(B) 10 N.

(C) 0.4 N.

(D) 40 N.

(E) 1.0 N.

Question$^{(3p)}$ 18. A point-like source of light S is placed near a thin diverging lens, not shown in the diagram below. The optical axis of the lens is depicted as a dashed line. The lens creates a virtual image of the object S'. Determine the focal length of the lens f, if known that the grid unit-cell is of dimension $1.0\ \text{cm} \times 1.0\ \text{cm}$.



(A) $f = 2.0$ cm

(B) $f = 4.0$ cm

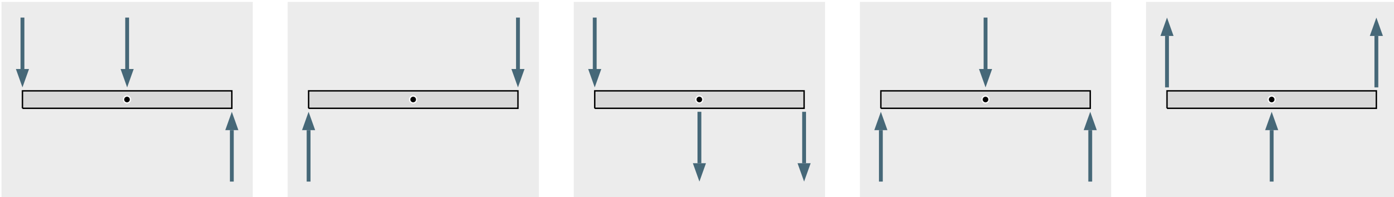
(C) $f = 8.0$ cm

(D) $f = 6.0$ cm

(E) $f = 9.0$ cm

Question$^{(3p)}$ **19.** Shown in arrows, forces of one intensity can act in either two senses along the direction perpendicular to a massless stick. Its ends/center are the points of force application. Which case leads to the static mechanical equilibrium of the stick if its center is acted to by yet another force of the same kind?

(A) (B) (C) (D) (E)



Question$^{(3p)}$ **20.** Electric potential at the tip of a square pyramid having uniform volumetric charge density ρ, of base area $2a \times 2a$ and height a, amounts φ_1. On the other hand, the electric potential at the center of a cube having the same volumetric charge density ρ and side a amounts φ_2. Determine ratio φ_2/φ_1.

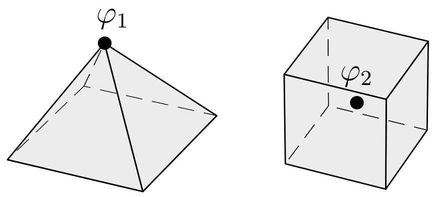
(A) $\varphi_2/\varphi_1 = 3/2$.

(B) $\varphi_2/\varphi_1 = 1/6$.

(C) $\varphi_2/\varphi_1 = 4/3$.

(D) $\varphi_2/\varphi_1 = 1/8$.

(E) $\varphi_2/\varphi_1 = 9/8$.



Question$^{(3p)}$ **21.** Projectiles A, B, and C are simultaneously thrown off a cliff to take the three trajectories, as shown. Neglecting air resistance, as well as eventual collisions, rank the times τ_A, τ_B, τ_C which the projectiles spend in the air till they hit the ground, respectively.

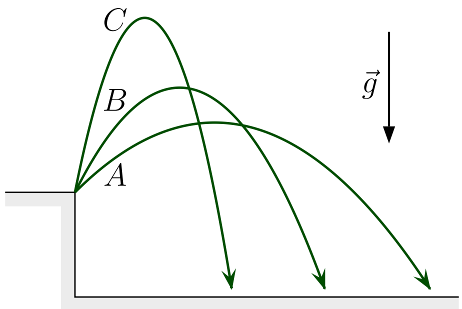
(A) $\tau_A > \tau_C > \tau_B$

(B) $\tau_C > \tau_A > \tau_B$

(C) $\tau_B > \tau_A > \tau_C$

(D) $\tau_C > \tau_B > \tau_A$

(E) $\tau_A > \tau_B > \tau_C$



Question$^{(3p)}$ **22.** A hockey puck is kicked up a long ramp, which makes an angle of $30°$ with the horizontal. The graph below depicts the speed of the puck (ordinate v) versus time (abscissa t); a segment of the $v(t)$ dependence. What is the coefficient of friction μ between the puck and the ramp?

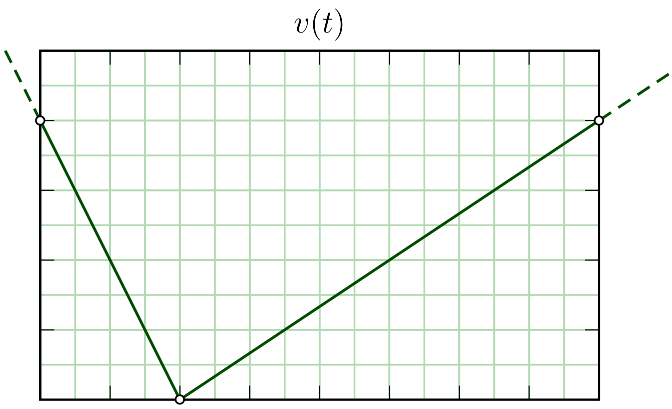
(A) $\mu = \sqrt{3}/2$

(B) $\mu = \sqrt{3}$

(C) $\mu = 1/3$

(D) $\mu = \sqrt{3}/6$

(E) $\mu = \sqrt{3}/3$



Question(3p) 23. You are in a floating boat on a water pond of mass density ρ_0. A block of mass density ρ is also in the boat. You chuck the block overboard into the pond. The water level of the pond will

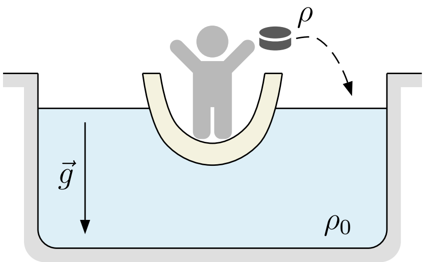
(A) rise a bit if $\rho_0 < \rho$.

(B) fall a bit if $\rho > \rho_0$.

(C) only change if $\rho_0 = \rho$.

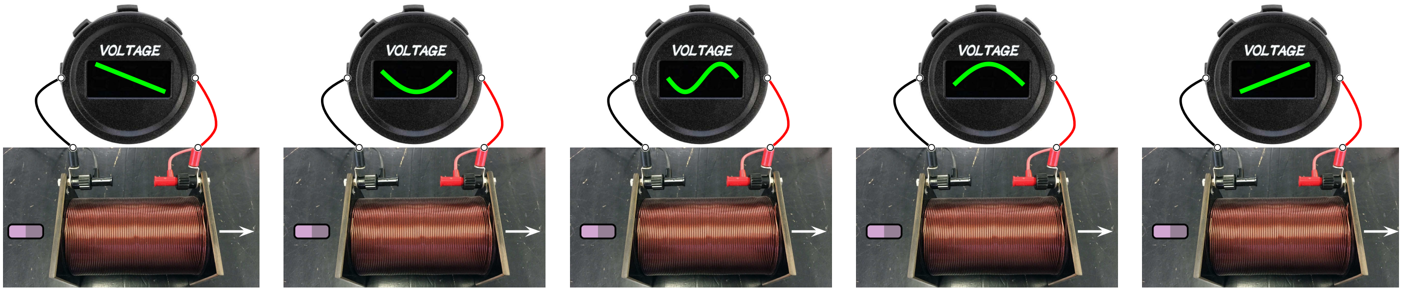
(D) never remain unchanged.

(E) always remain unchanged.



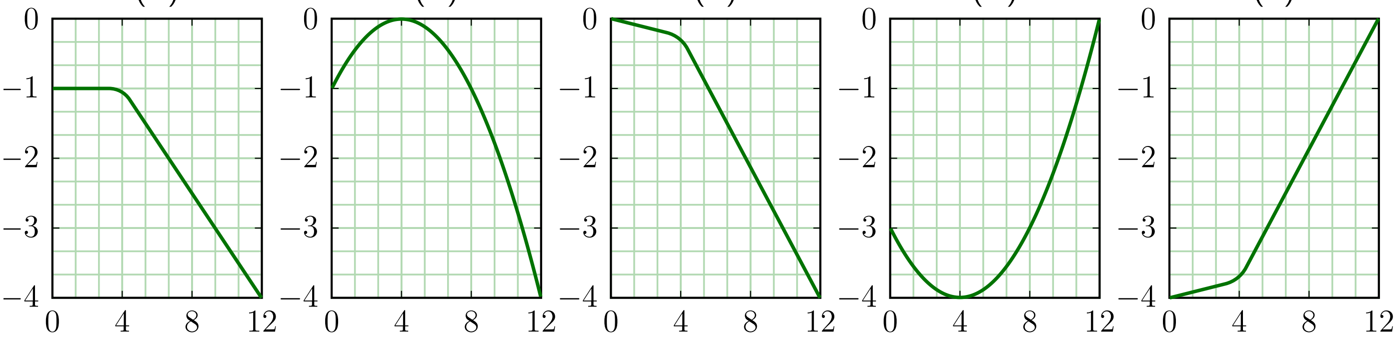
Question(3p) 24. Shown as a green curve on a voltage display, the time variation of the electromotive force induced in a solenoid, when a short permanent magnet bar is travelling with uniform speed axially along the solenoid full length, is best represented in?

(A) (B) (C) (D) (E)



Question(4p) 25. Temperature dependence of $\frac{10\rho(t)}{\mathrm{kg/m^3}} - 10\,000$ as the ordinate versus $\frac{t}{^\circ\mathrm{C}}$ as the abscissa of fresh water is given in the diagrams below, where $\rho(t)$ stands for the water density measured in $\mathrm{kg/m^3}$ at a given temperature t expressed in degrees Celsius. Single out the diagram that is most likely correct.

(A) (B) (C) (D) (E)



Question(4p) 26. A builder wants to construct a stable corbelled arch stacking identical bricks so that each brick overhangs the one below it, as shown in the figure. What minimum number of bricks, each $d = 30$ cm long and uniform, is needed if the arch is to span $\ell = 1.0$ m? You may use $\sum_{i=1}^{i=15} 3/(10i) = 0.995468698$.

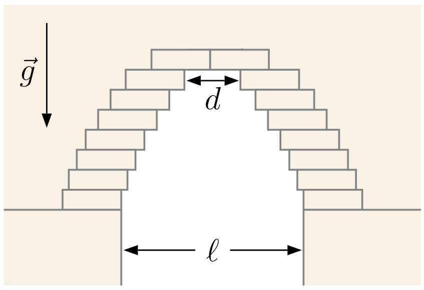
(A) 35

(B) 34

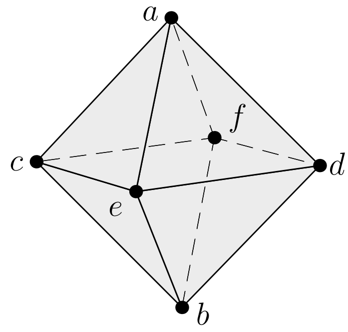
(C) 30

(D) 36

(E) 32



Question(4p) 27. Twelve identical resistors are arranged along the edges of a regular octahedron network, which is composed of eight equilateral triangles (octahedron faces), four of which meet at each of the six symmetrically equivalent nodes. Let R_{xy} be the equivalent electric resistance measured between two different nodes x and y, either adjacent or opposite, where $x, y \in \{a, b, c, d, e, f\}$. Find the incorrect expression among the listed.



(A) $R_{ab} = R_{cd}$

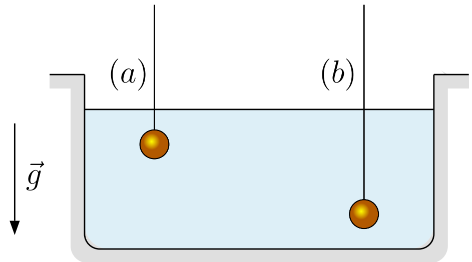
(B) $R_{ac} = R_{ae} = R_{ad} = R_{af} < R_{ab}$

(C) $R_{cd} = R_{ef}$

(D) $R_{ce} = R_{ed} = R_{df} = R_{fc} < R_{cd}$

(E) $R_{ab} > R_{ef}$

Question(4p) 28. A spherical copper ball at 20° C hanging on a thin thermally insulated string is immersed in a large amount of water at 80° C, thermally insulated by a container. After a time of τ_1 the copper ball warms up to 50° C. Later the experiment is repeated in such a way that the initial temperature of water is 20° C, while the ball is at 80° C. In this way, the copper ball cools down to 50° C during a time of τ_2. Which pair of the relationships between $\tau_1^{(i)}$ and $\tau_2^{(i)}$ is correct if the ball is just immersed in the water close to its surface (case $i = a$), or is submerged almost to the bottom of the container (case $i = b$)?



(A) $\tau_1^{(a)} < \tau_2^{(a)}$ and $\tau_2^{(b)} < \tau_1^{(b)}$

(B) $\tau_1^{(a)} > \tau_2^{(a)}$ and $\tau_2^{(b)} < \tau_1^{(b)}$

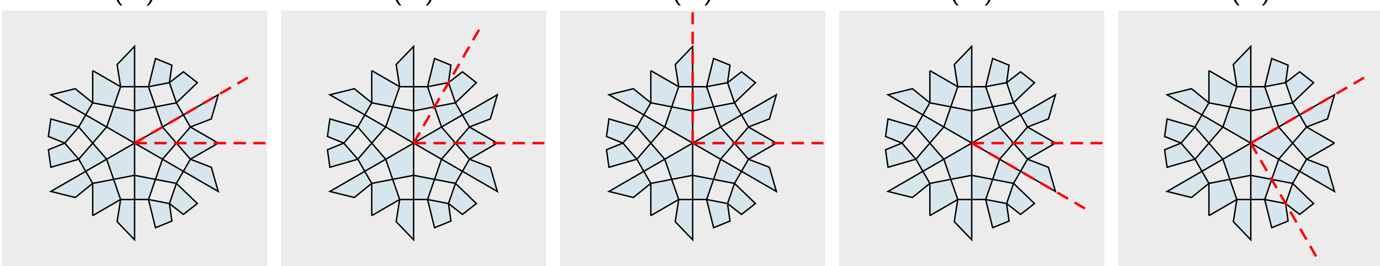
(C) $\tau_1^{(a)} < \tau_2^{(a)}$ and $\tau_2^{(b)} > \tau_1^{(b)}$

(D) $\tau_1^{(a)} > \tau_2^{(a)}$ and $\tau_2^{(b)} > \tau_1^{(b)}$

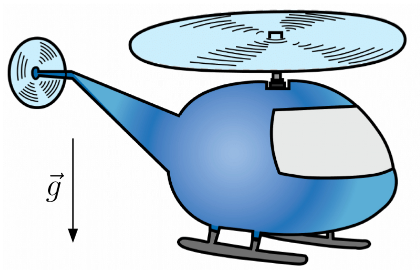
(E) $\tau_1^{(a)} = \tau_2^{(a)}$ and $\tau_2^{(b)} = \tau_1^{(b)}$

Question(4p) 29. You look into a kaleidoscope. Part of the observed view is shown in the figure. Where are the mirrors (dashed lines in red)? A kaleidoscope is an optical tool with two or more reflecting surfaces tilted to each other at an angle, so that one or more parts of objects on one end of these mirrors are shown as a regular symmetrical pattern when viewed from the other end, due to the repeated reflections.

(A) (B) (C) (D) (E)



Question(4p) 30. A certain helicopter is hovering. The required power of the mechanical output for that is P_0. If an exact replica is made, where all linear dimensions have been doubled, what would be the new power P of the mechanical output required for hovering?



(A) $P = P_0$.

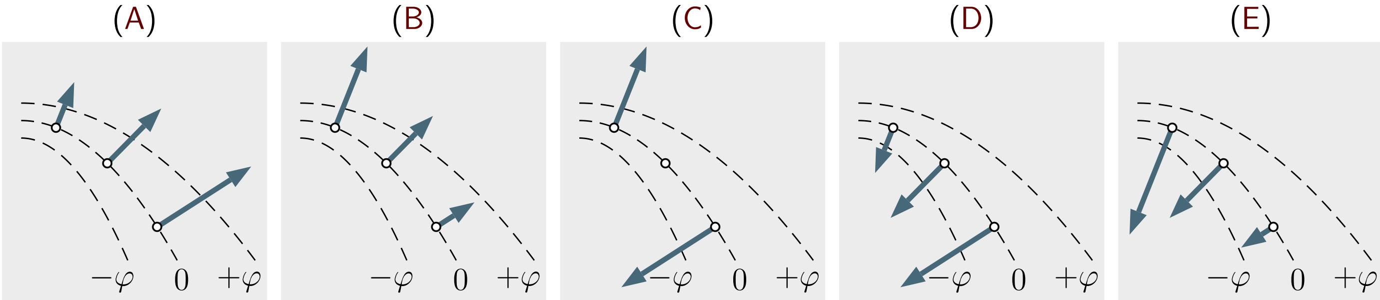
(B) $P = 2^{3/2} \times P_0$.

(C) $P = 2^{5/2} \times P_0$.

(D) $P = 8 \times P_0$.

(E) $P = 2^{7/2} \times P_0$.

Question$^{(4p)}$ **31.** Sketched below are three equipotential surfaces: $-\varphi$, 0, and $+\varphi$, where $\varphi = 100\ \mathrm{mV}$. What set of the electric field vectors (given in arrows) at the zero-potential surface fits best the spatial configuration of the electric potential?



Question$^{(4p)}$ **32.** A room is illuminated by a five-arm chandelier, attached to the ceiling. A symmetrical double convex hand-held magnifying glass lies on the desk in the room. A glance at the magnifying glass reveals two images of the chandelier at different magnifications and orientations: $\mathscr{I}_1$ (larger) and $\mathscr{I}_2$ (smaller). Which statement is false regarding the origin/nature of the two created images and the directions which the arms of the chandelier point into in reality?

(A) $\mathscr{I}_1$ shows correctly how the chandelier arms are oriented in reality.

(B) $\mathscr{I}_1$ is real.

(C) $\mathscr{I}_2$ is real.

(D) $\mathscr{I}_1$ is due solely to one reflection.

(E) $\mathscr{I}_2$ is due to both reflection and refraction.