SJRD 2024

GENERAL DATA SHEET (unless otherwise stated in the problems)

Acceleration due to gravity at the surface of Earth, $g = 9.81\ m\ s^{-2}$

Universal gravitational constant; $G = 6.67 \times 10^{-11}\ kg^{-1}\ m^3\ s^{-2}$

Universal gas constant, $R = 8.31\ J\ mol^{-1}\ K^{-1}$

Vacuum permittivity, $\varepsilon_0 = 8.85 \times 10^{-12}\ C^2\ N^{-1}\ m^{-2}$

Vacuum permeability, $\mu_0 = 4\pi \times 10^{-7}\ T\ m\ A^{-1}$

Atomic mass unit, $u = 1.66 \times 10^{-27}\ kg$

Speed of light in vacuum, $c = 3.00 \times 10^8\ m\ s^{-1}$

Speed of sound in air, $v_s = 340\ m\ s^{-1}$

Elementary charge, $e = 1.60 \times 10^{-19}\ C$

Planck's constant, $h = 6.63 \times 10^{-34}\ J\ s$

Boltzmann constant, $k = 1.38 \times 10^{-23}\ J\ K^{-1}$

Avogadro's number, $N_A = 6.02 \times 10^{23}\ mol^{-1}$

Standard atmosphere pressure, $P_0 = 1.01 \times 10^5\ Pa$

Stefan-Boltzmann constant, $\sigma = 5.67 \times 10^8\ W\ m^{-2}\ K^{-4}$

Question 1

Not yet answered

Flag question

A lift travels upwards at a constant velocity of 8.0 m s^{-1}.

The ceiling of the lift is a height 3.0 m above the floor of the lift.

At time *T*, a bolt is dislodged from the ceiling of the lift and falls freely.

How many seconds after *T* does the bolt hit the floor of the lift?

Ignore the effect of air resistance.

- 1.95 s
- 1.53 s
- 2.13 s
- 0.78 s
- 0.61 s

Question 2

Not yet answered

Flag question

A rocket lifts-off and continues with a uniform upward acceleration of 1.50 m s^{-2} until it reaches an altitude of 1.20 km.

At that point, the payload is released from the rocket and undergoes free-fall.

Determine the maximum altitude reached by the payload. (Neglect air resistance.)

- ○ 1380 m
- ○ 1560 m
- ○ 1412 m
- ○ 1357 m
- ○ 1203 m

?

Question 3

Not yet answered

Flag question

A ship travels due East at a constant speed of 10 km h^{-1}.

A second ship travels at a heading of 30° East of North and its position is **always due North** of the first ship.

What is the speed of this second ship?

- 15 km h^{-1}
- 12 km h^{-1}
- 10 km h^{-1}
- 17 km h^{-1}
- 20 km h^{-1}

Question 4

Not yet answered

Flag question

Two balls are on a large horizontal field and are both kicked off the ground at an angle of 30° above the horizontal.

The initial speed of Ball 2 is **twice** that of Ball 1.

Ball 1 lands a distance D_1 away, while Ball 2 lands a distance D_2 away.

What is the ratio D_2/D_1? (Ignore air resistance.)

- 2
- 4
- 1
- 8
- 10

Question 5

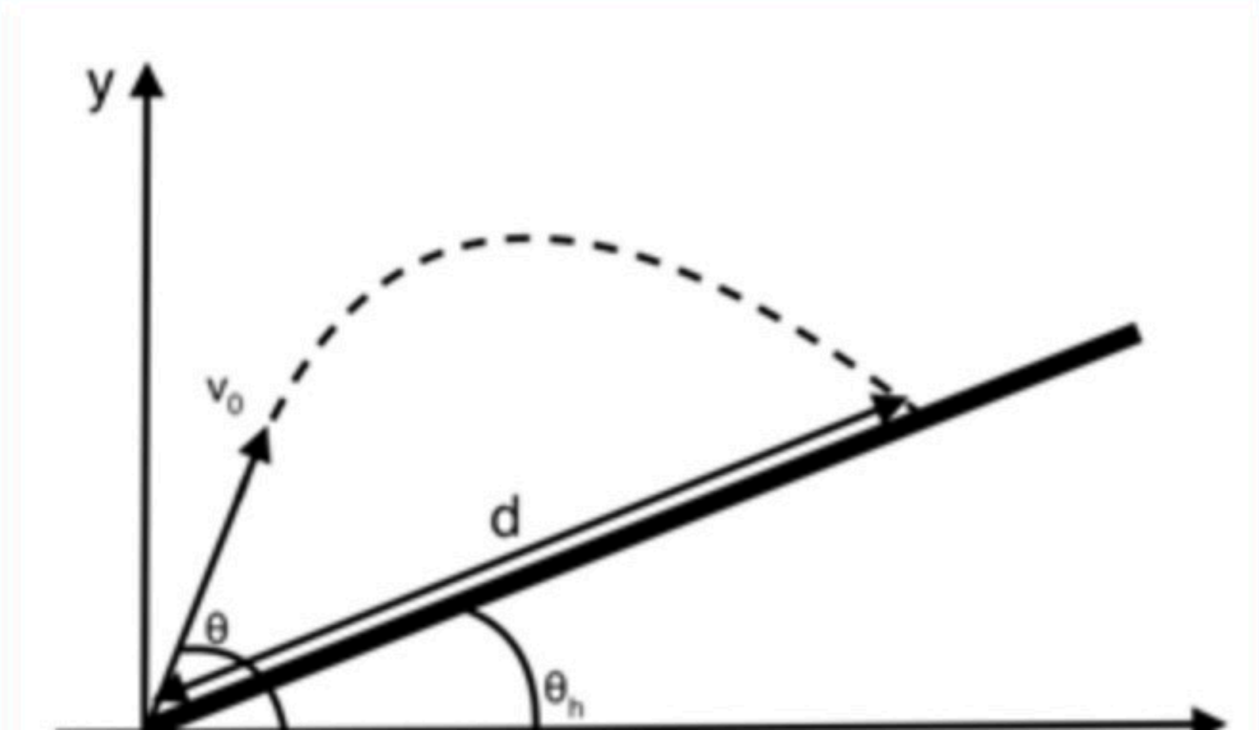
Not yet answered

Flag question

A ball is thrown from the ground with initial speed v_0 = 33 m s^{-1} at an angle θ = 65° above the horizontal.

The ball lands on a slope that is inclined uniformly at an angle of θ_h = 28° above the horizontal.

What is the distance, d, measured along the slope to where the ball landed? (Ignore air resistance.)



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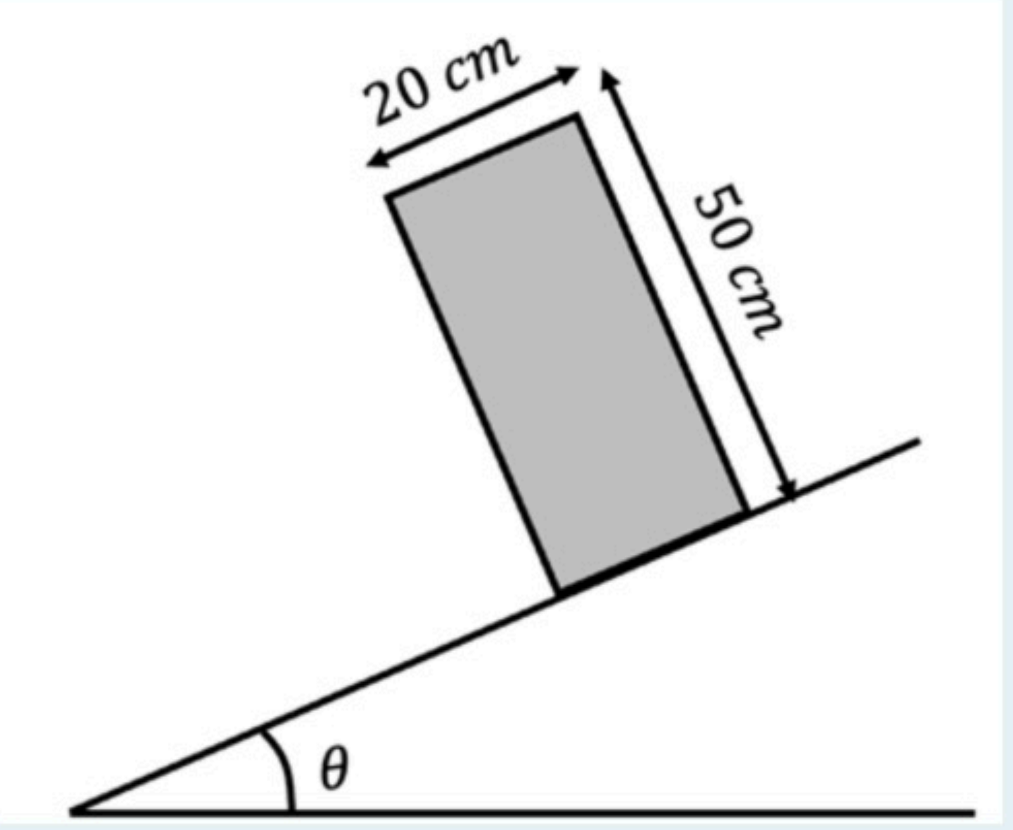
Question 6

Not yet answered

Flag question

A uniform rectangular block rests on a very rough inclined plane.

What is the maximum angle of tilt θ before the block topples over?



- 11.3°
- 68.2°
- 51.3°
- 21.8°
- 38.7°

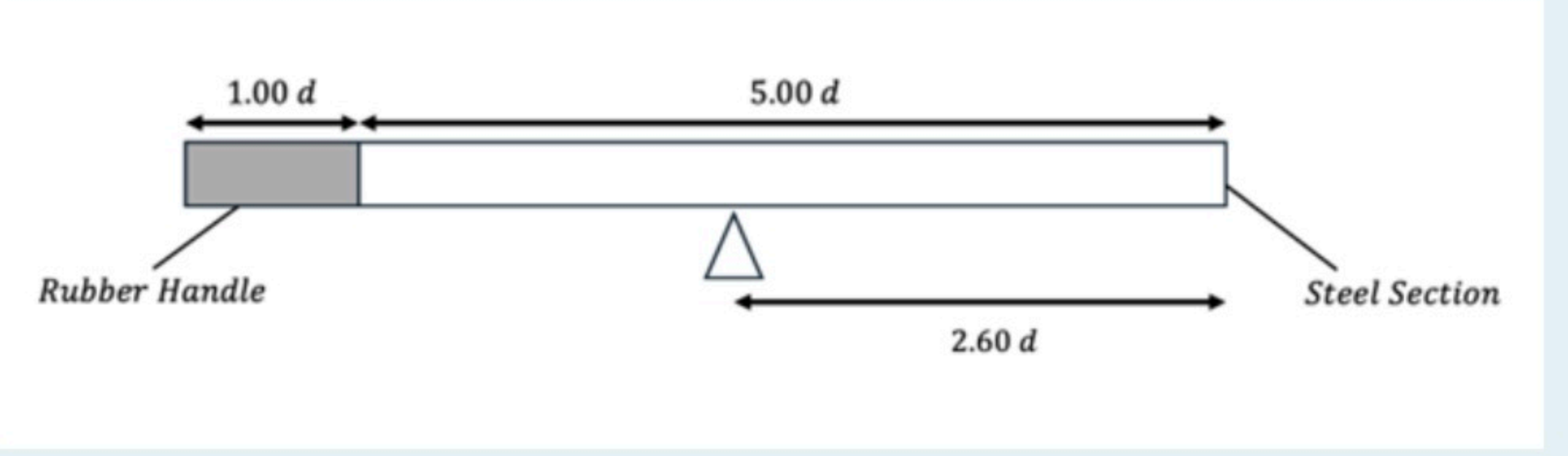
Question 7

Not yet answered

Flag question

A rod is made up of two different materials, a rubber handle and a steel section. The rubber is uniform throughout the handle and the steel is uniform throughout the section.

The length of the handle is *d*, and the length of the steel section is 5.0 *d*. The entire rod has a uniform cross-sectional area. The rod balances horizontally when pivoted at a distance of 2.6 *d* from the steel end.



What is the ratio $\frac{Density\ of\ Steel}{Density\ of\ Rubber}$?

- 4.8
- 5.0
- 3.8
- 4.0
- 5.8

Question 8

Not yet answered

Flag question

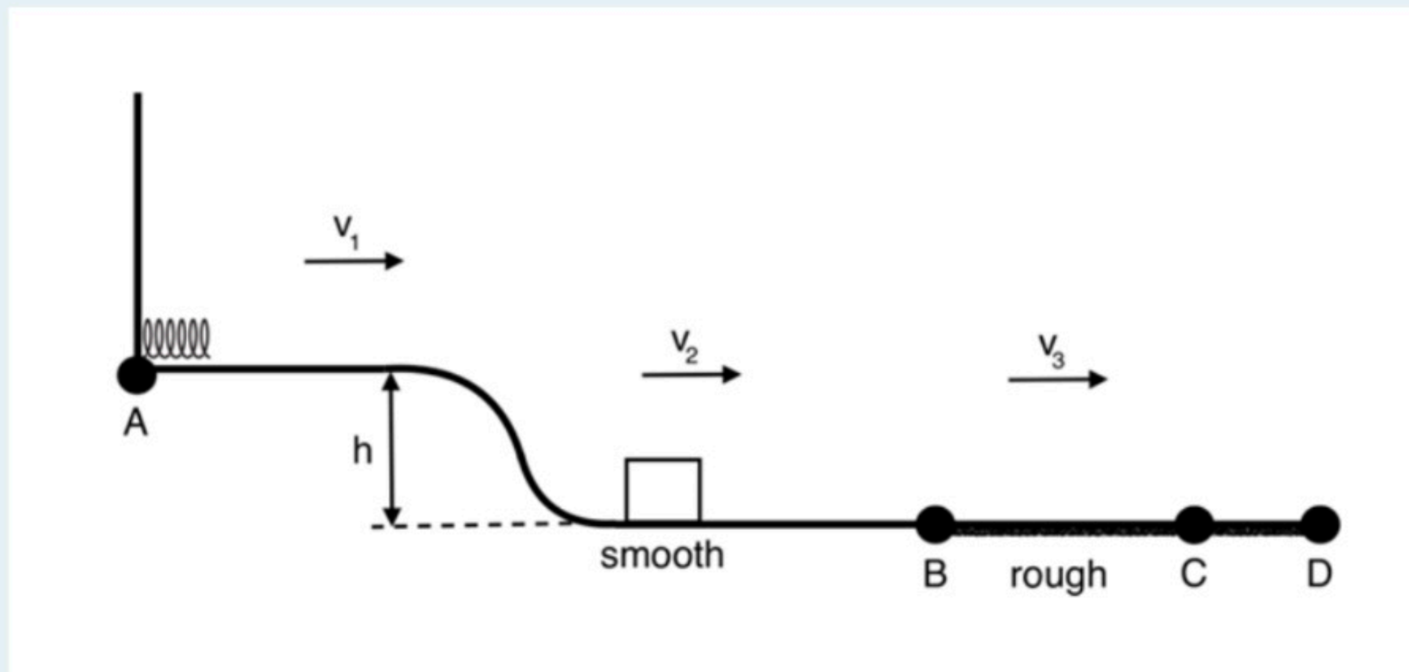
There is an ideal spring with one end fixed to a wall at point A. Determine the spring **constant**.

Time left ↑ fill in the blanks

Show

You are given the following information:

- The ground is frictionless between points A and B.
- A horizontal force of 67 N is exerted to hold a 0.80 kg block in place against the spring at point A.
- When this horizontal force is removed, the block leaves the spring with a velocity v_1 = 1.2 m s^{-1} to the right.
- The block slides smoothly without friction and attains a velocity v_2 = 1.9 m s^{-1} just before it reaches point B.
- The block then enters a rough section at point B, which extends to point D. The coefficient of friction for this section has a constant value μ = 0.39.
- The velocity of the block when it passes point C is v_3 = 1.4 m s^{-1}.
- The block comes to rest at point D.



- 2.9 kN m^{-1}
- 3.9 kN m^{-1}
- 7.8 kN m^{-1}
- 1.6 kN m^{-1}
- 4.7 kN m^{-1}

Question 9

Not yet answered

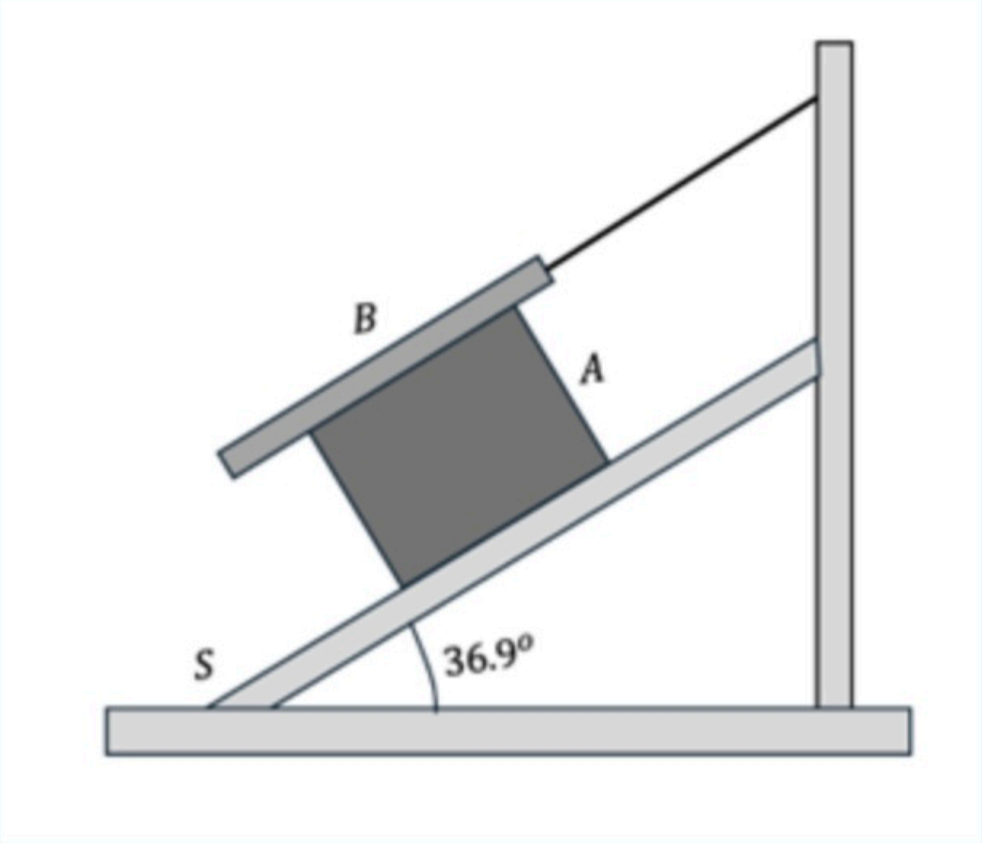
Flag question

An inclined plane **S** has a constant slope angle of 36.9° above the horizontal.

Block **A** has weight 3 W and is sandwiched below plank **B** of weight W. Note that plank **B** is attached to a fixed vertical structure shown on the right of the diagram via a taut string that is parallel to plane **S**.

Assume that the **coefficient of kinetic friction** μ_k is the same between block **A** and plank **B** as it is between block **A** and plane **S**.

Plank **B** is stationary and block **A** slides down the plane at constant speed. Determine the value of μ_k.



- 0.36
- 0.55
- 0.58
- 0.48
- 0.45

Question **10**

Not yet answered

Flag question

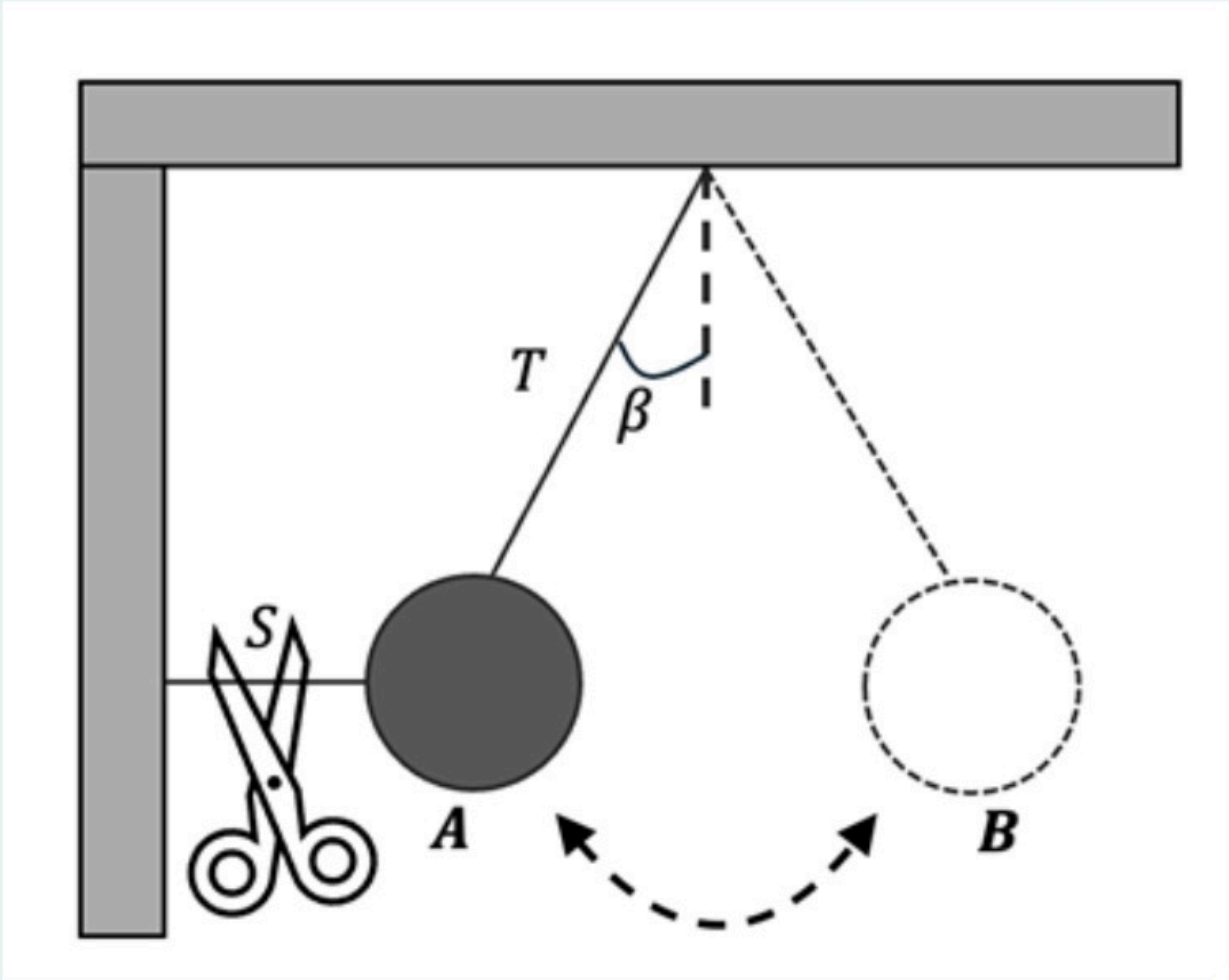
Time left Show

A ball is initially held at rest at position A by two light strings, S and T. String S is horizontal and string T is at an angle $\beta = 30°$ from the vertical.

The horizontal string S is cut, and the ball starts to swing as a pendulum.

Position B is the farthest to the right that the ball can go as it swings back and forth.

What is the ratio of the magnitude of the tension in string T when the ball is at position B to the magnitude of the tension in string T when the ball was at position A **before** string S was cut?



- 0.75
- 0.30
- 0.25
- 0.50
- 0.87

Question 11

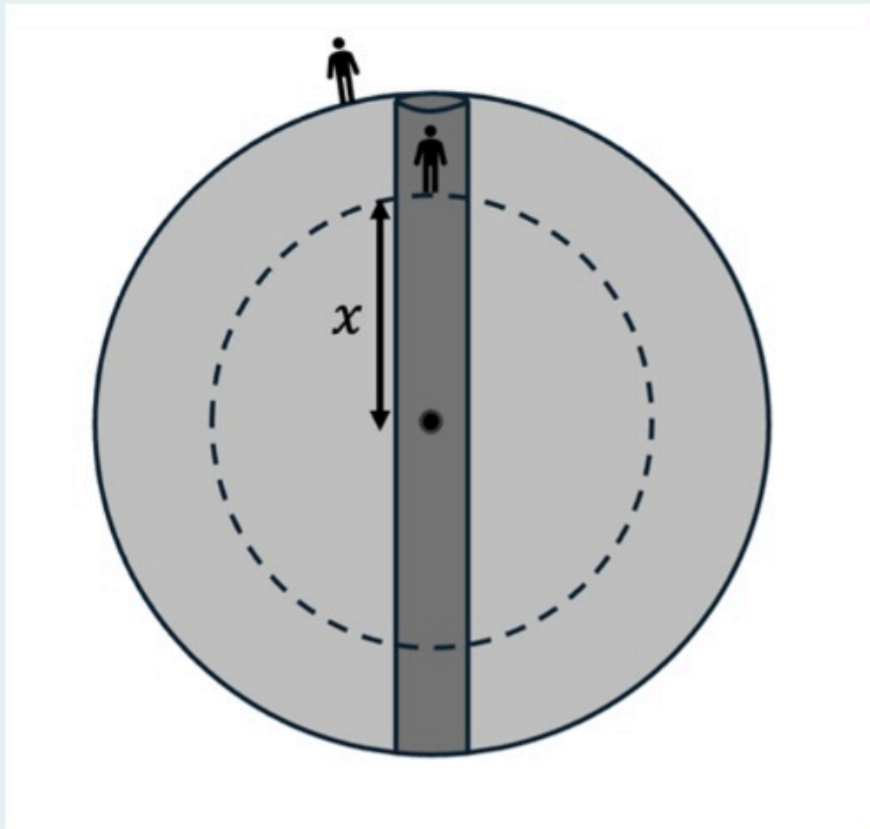
Not yet answered

Flag question

Newton's Shell Theorem states that a body **inside** a uniform spherical shell of mass, regardless of the position of the body, will not experience any net gravitational force due to the shell of mass. In contrast, a body **outside** a uniform spherical shell of mass will experience a net gravitational force due to the shell of mass, and this force will be as if all the mass of the shell were concentrated at the very centre of the shell.

A man falls through a narrow tunnel which runs along a radius right through to the centre of the Earth. The man's mass is taken to be m = 80.0 kg and the radius of the Earth is R = 6.37×10^{6} m. For this problem, assume that the Earth has **uniform density** everywhere, i.e., the mass of the Earth, M = 5.97×10^{24} kg, is **uniformly distributed** throughout its volume.

Determine the speed of the man when he is at the **midpoint** between the centre of the Earth and his starting position at rest on the surface of the Earth.



- 3.42 km s^{-1}
- 6.85 km s^{-1}
- 11.2 km s^{-1}
- 9.68 km s^{-1}
- 7.91 km s^{-1}

Question **12**

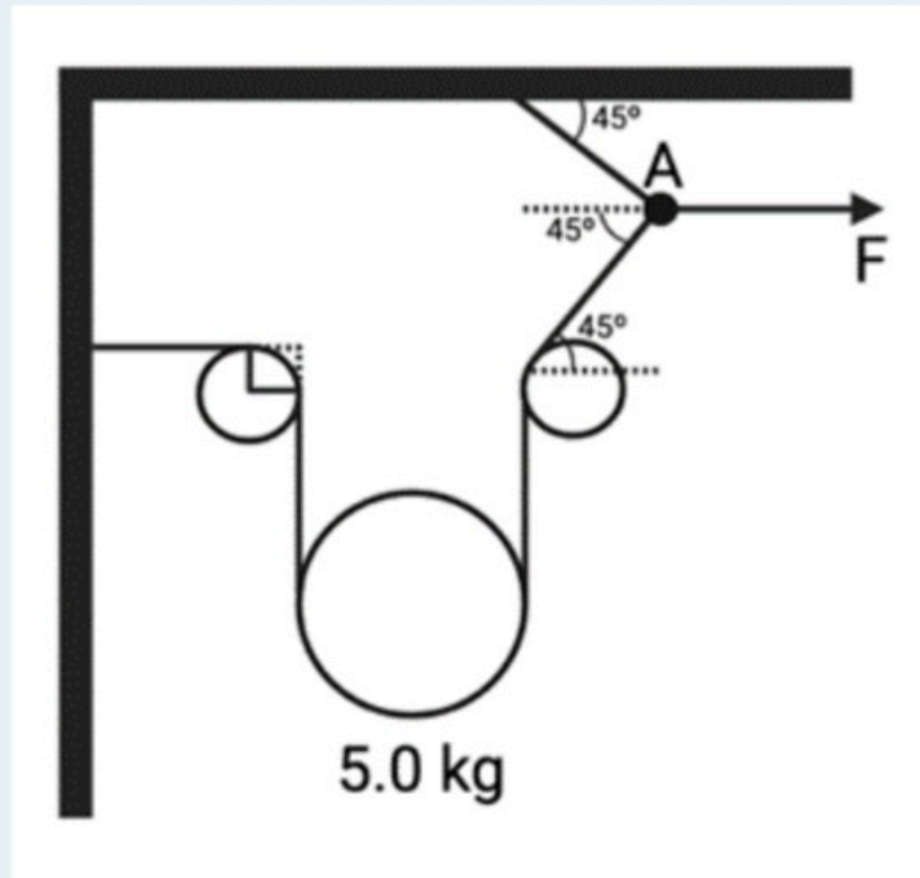
Not yet answered

Flag question

A pulley system consists of one large 5.0 kg pulley that is freely suspended on the string and two other fixed pulleys.

A single string runs from the wall to the ceiling, as shown in the diagram. At the wall end, the string is **horizontal**, and the string is **vertical** on both sides of the large pulley. At point **A**, a horizontal force *F* is applied to the right, giving rise to the 45° angles shown.

Given that the string is taut and the entire system is stationary, find the magnitude of force *F*.



- 25 N
- 69 N
- 49 N
- 74 N
- 35 N

Question 13

Not yet answered

Flag question

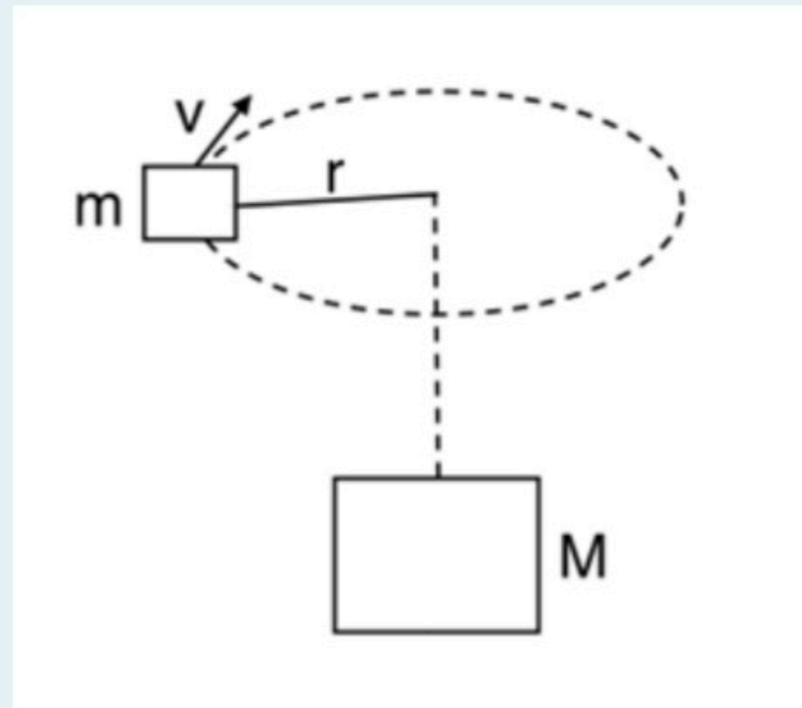
A small block of mass *m* moves frictionlessly on a horizontal surface.

There is a hole in the surface, through which a light, inextensible string is passed.

The string connects the small block to a large block of mass *M*. This large block hangs **vertically** below the hole, as shown in the diagram below.

If the small block undergoes **uniform circular motion** with radius *r* while the large block is stationary, find an expression for the linear speed *v* of the small block.

Denote the acceleration of free-fall as *g*.



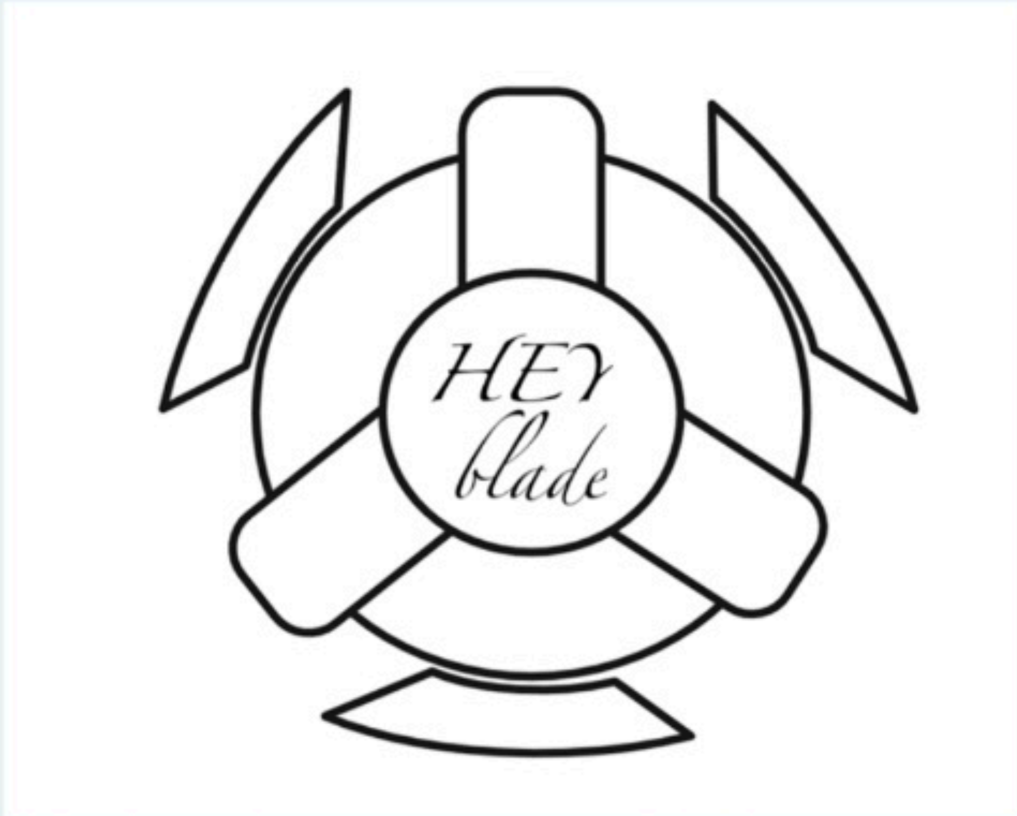
- $\sqrt{\frac{Mr}{mg}}$
- \(\sqrt \frac{Mgr}{m} \)
- \(\sqrt \frac{mg}{Mr} \)
- \(\sqrt \frac{mr(1-g)}{M} \)
- \(\sqrt \frac{M}{mgr} \)

Question 14

Not yet answered

Flag question

The popular toy *Heyblade* is basically a spinning top. Players compete to see which top remains spinning for the longest time. A top-view diagram of a *Heyblade* is shown below.



The term "spin stealing" is used in competitive circles to describe a possible interaction between two *Heyblades*. Spin stealing occurs when a slowly spinning top **spins faster** after a collision with another spinning top. Assume both tops are on horizontal ground and have **vertical** spin axes.

Which of the following options are **true** of spin stealing?

1. Spin stealing does **not** conserve angular momentum because when the tops collide, the contact force between the tops is an external force that produces a torque.
2. Lining the rim of the top with **rubber** allows it to spin-steal more effectively.
3. Spin stealing only occurs when the tops are spinning in **opposite orientations** (e.g., one clockwise and the other anticlockwise).
4. Spin stealing only occurs when the tops are spinning in the **same orientation** (e.g., both clockwise or both anticlockwise).

- 1, 2 and 4 only
- 2 and 4 only
- 3 only
- 2 and 3 only
- 4 only

Question **15**

Not yet answered

Flag question

Randy drives a sports car with total mass of 1570 kg (including the driver). The wheels of the car each have a diameter of 50 cm and can collectively exert a maximum frictional force of 10 000 N.

Randy the stunt driver turns off traction control, hence allowing the wheels to keep spinning even if they are slipping. Flooring the accelerator pedal, a terrible screeching ensues as the wheels slip against the road surface.

In this manner, the car slowly accelerates forward from rest while Randy floors the accelerator pedal, keeping the wheels spinning at a constant 500 revolutions per minute, until the wheels finally gain traction (i.e., the wheels no longer slip against the ground).

Determine the distance travelled by the car before the wheels gained traction. (Neglect air resistance.)

- 18.0 m
- 1230 m
- 13.5 m
- 27.0 m
- 53.0 m

Question 16

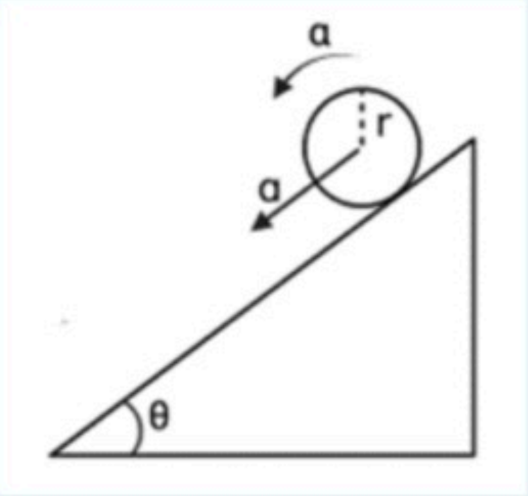
Not yet answered

Flag question

A coin has mass *m*, radius *r*, and thickness *t*. Treat the coin as a uniform solid cylinder. Denote the gravitational acceleration as *g*.

The coin rolls without slipping from the top of a slope which has an angle of inclination θ. The slope is sufficiently rough such that the coin **rolls without slipping** (i.e., there is no relative movement between the point of contact of the coin and the slope surface).

What is the expression for the **linear acceleration** of the coin?



- $\frac{2g\sin\theta}{3}$
- $\frac{g\sin\theta}{1+\frac{r}{t}}$
- $\frac{g\sin\theta}{1+\frac{r^2}{t^2}}$
- $g\sin\theta$
- $\frac{3g\sin\theta}{2}$

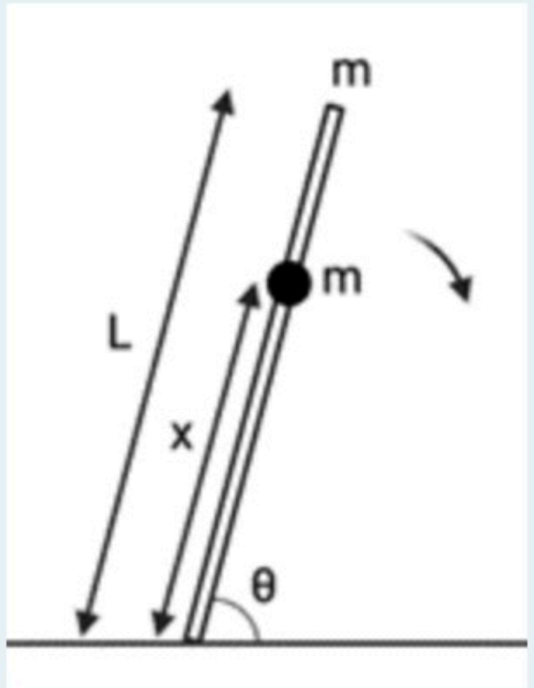
Question 17

Not yet answered

Flag question

A thin rod of uniform density has length L and mass m. A point mass, also of mass m, is placed a distance x away from the base of the rod.

The rod, with the point mass securely attached to it, is dropped from a fixed angle θ, as shown below. Assume the end of the rod in contact with the ground is very rough and **does not slip** throughout the motion.



Which of the following values of x causes the rod to take the **shortest time** to fall to a horizontal orientation?

- $\frac{3}{4}L$
- 0
- $\frac{1}{2}L$
- L
- $\frac{1}{4}L$

Question 18

Not yet answered

Flag question

An incompressible, frictionless fluid flows through a horizontal pipe whose cross-section narrows from area A to area $\frac{A}{2}$.

How does the flow speed v and the pressure p change as the fluid goes from the thicker to the narrower section of the pipe?

- v halved, p quadrupled
- v doubled, p quartered
- v doubled, p halved
- v unchanged, p doubled
- v halved, p doubled

Question 19

Not yet answered

Flag question

Suppose the Earth is a perfect absorber of the Sun's radiation. Assume that based on the distance from the Sun to the Earth, the received radiation from the Sun has a power per unit area of 1.3 kW m^{-2}.

Determine the temperature of the Earth in this model. You may take the radius of the Earth to be 6370 km.

- 298 K
- 270 K
- 250 K
- 275 K
- 288 K

Question 20

Not yet answered

Flag question

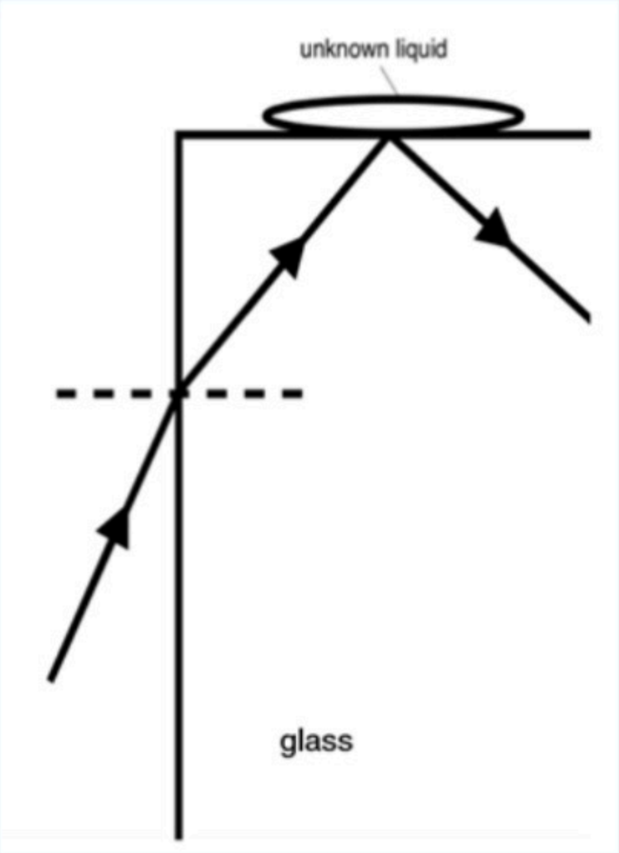
The top surface of a rectangular block of glass is coated with a thick layer of unknown liquid.

Time left Show

The refractive index of the glass is 1.52, and the refractive index of air is 1.

A laser beam, with wavelength 532 nm, enters the side of the block as shown in the diagram. It was found that 36.9° was the largest angle of incidence at the side of the block such that the laser undergoes **total internal reflection** at the interface between the glass and the unknown liquid.

Determine the speed of light in the unknown liquid.



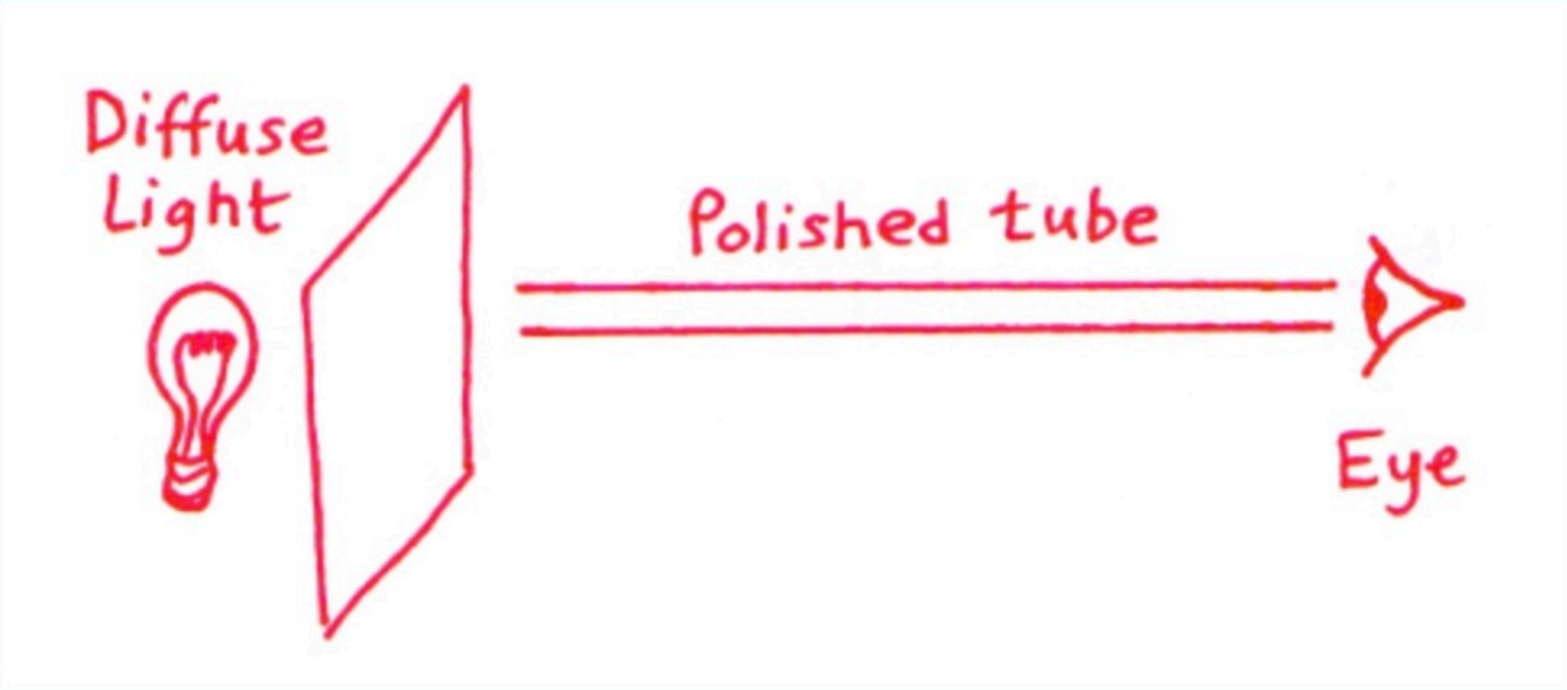
- 2.88×10^{8} m s^{-1}
- 2.15×10^{8} m s^{-1}
- 2.32×10^{8} m s^{-1}
- 2.53×10^{8} m s^{-1}
- 1.97×10^{8} m s^{-1}

Question **21**

Not yet answered

Flag question

With your eye aligned with the central axis of a long, thin metal tube whose inner surface is polished to a mirror sheen, you will see a pattern of rings when looking towards a diffuse source of light. (Drawing by Professor Povey.)



At the centre you see a bright circle, surrounded by rings that are successively less bright. The circle is brighter than the first ring, which is brighter than the second ring, and so on.

Suppose the tube has inner diameter of 2 cm and a length of 95 cm.

For the **second ring**, at what angle is it from the central axis?

- 0.03°
- 1.8°
- 0.01°
- 0.6°
- 1.2°

Question 22

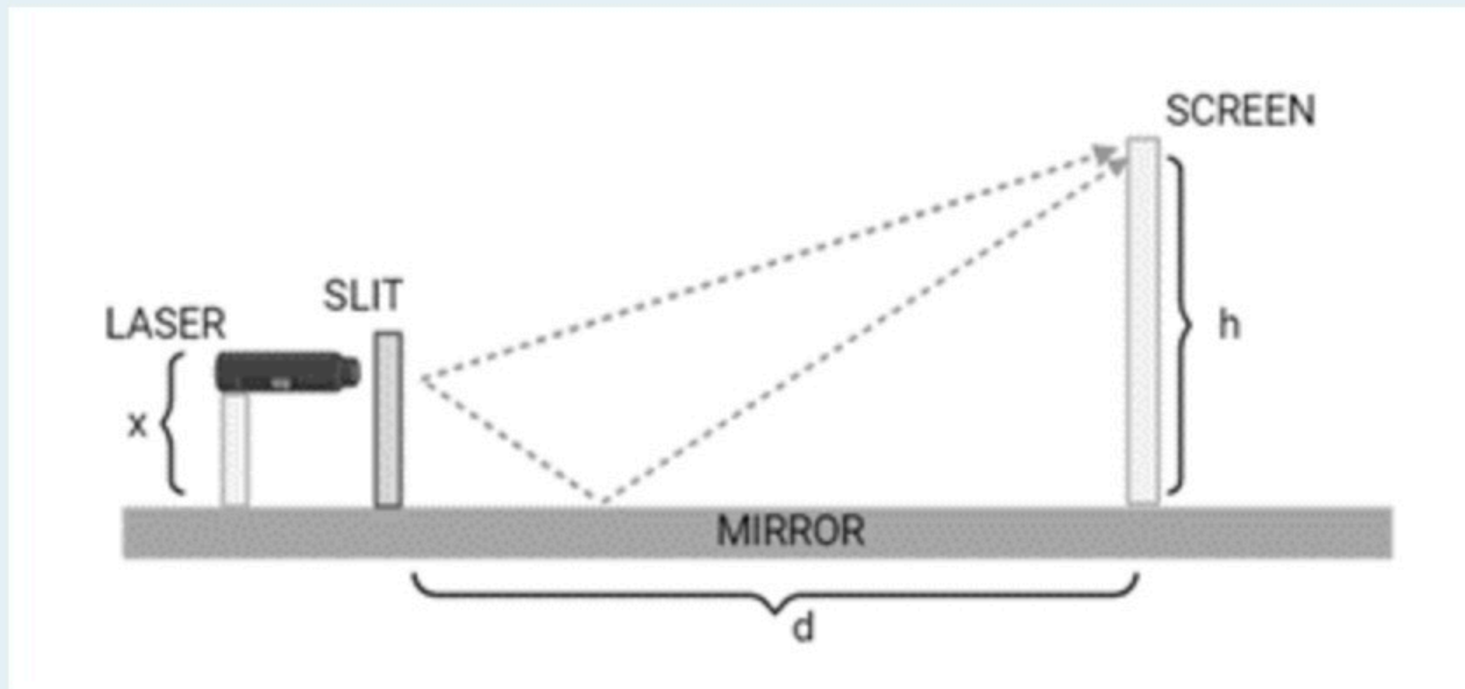
Not yet answered

Flag question

A laser emits monochromatic light of wavelength λ. The laser is mounted a distance x above a plane mirror, and the beam diffracts through a thin slit.

Consider the interference between the laser light that is directly incident on the screen and the laser light that reflects off the mirror. Note that there is a π phase shift upon reflection.

What is the **maximum** wavelength λ such that there is **constructive interference** at a height h on the screen? Assume that the distance to the screen d is much greater than both x and h.



- xh/d
- $8xh/d$
- $2xh/d$
- $xh/2d$
- $4xh/d$

Question **23**

Not yet answered

Flag question

Unpolarised light is incident on a stack of linear polarising filters.

The polarisation axes of the second and third filters are respectively rotated 15.0° clockwise and 58.0° clockwise, relative to the polarisation axis of the first filter.

The light intensity is 45.0 W m^{-2} after it passes through this stack.

Now, the second filter is **removed** and the incident intensity of unpolarised light is **halved**. What is the light intensity that now passes through this stack (of two filters)?

- 42.1 W m^{-2}
- 12.7 W m^{-2}
- 24.1 W m^{-2}
- 16.9 W m^{-2}
- 50.5 W m^{-2}

Question 24

Not yet answered

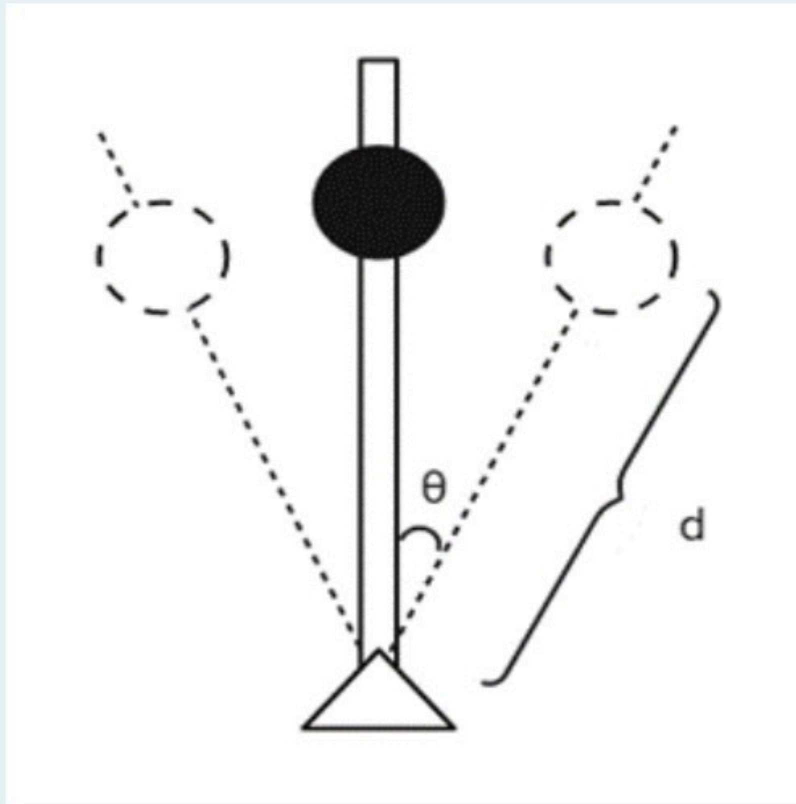
Flag question

Time left Show

A rigid, smooth rod is pivoted at one end. There is some spring mechanism in the base containing the pivot, so the rod can undergo simple harmonic motion for small angles θ.

The rod has a small protrusion a distance *d* from the pivot, such that a small bead of mass *m* can stay at distance *d*. This bead cannot get past the protrusion, but can easily slide off the free end of the rod.

Beyond a threshold oscillation frequency f, the bead **flies off the rod**. If the distance *d* doubles, what happens to f?



- Multiplied by a factor of $\sqrt{2}$
- Unchanged
- Multiplied by a factor of 2
- Multiplied by a factor of $\frac{1}{2}$
- Multiplied by a factor of $\frac{1}{\sqrt{2}}$

Question 25

Not yet answered

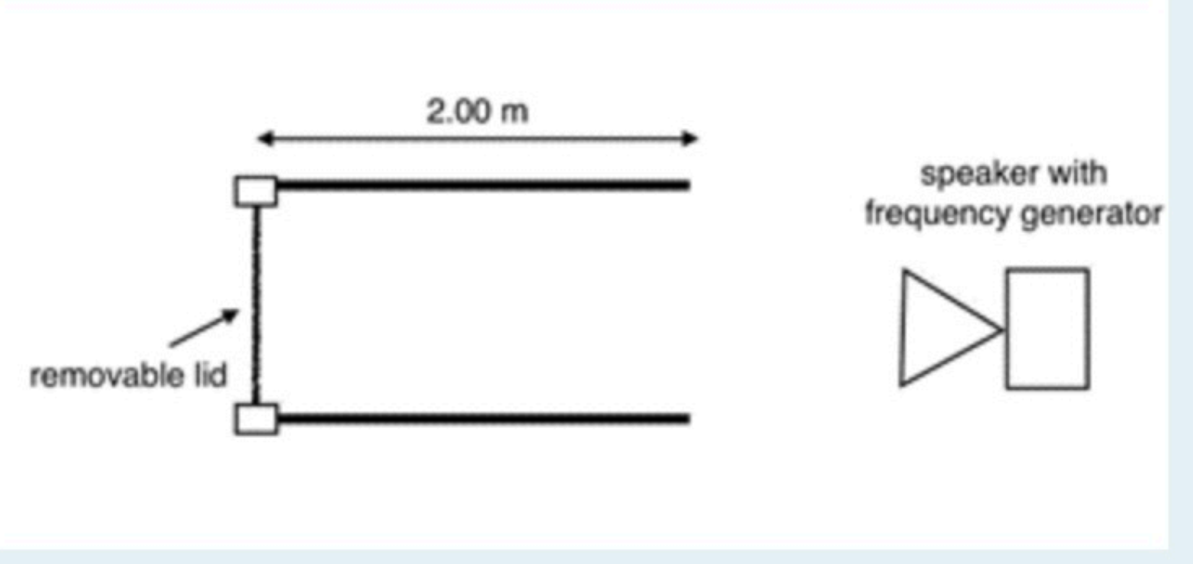
Flag question

A pipe of length 2.00 m has one open end as shown below. The **closed end** is sealed by a removable lid of negligible thickness.

A speaker connected to a frequency generator is placed beside the open end of the pipe. The sound frequency f is increased from zero until N loud sounds are heard, each at specific frequencies. The difference in the frequencies between the N^{th} loud sound and the first loud sound is $\Delta f = 510$ Hz.

Now, the frequency generator is reset, and the lid is **removed** from the pipe. The frequency is increased again from zero, until N loud sounds are heard.

Given that there are the **same number** of loud sounds heard this time as when the lid was sealed, determine the frequency of the N^{th} loud sound for the completely open pipe with the removed lid.



- 340 Hz
- 510 Hz
- 595 Hz
- 680 Hz
- 553 Hz

Question 26

Not yet answered

Flag question

A spool consists of an inner cylinder concentric with two larger discs. A length of ribbon is wrapped around the inner cylinder of radius 2.0 cm, such that the free end of the ribbon emerges from the lower surface of the cylinder (see photo). The outer discs of the spool, with radius 3.0 cm, allow it to **roll without slipping** on a horizontal surface.

When the ribbon is pulled in a direction that is almost horizontal, the spool rolls forward. When the ribbon is pulled in a direction that is almost vertical, the spool rolls backwards. (Photo below by Carl E. Mungan.)

What is the angle above the horizontal at which to pull the ribbon such that the spool would tend to **spin in place**?

- 30°
- 42°
- 48°
- 45°
- 34°

Question 27

Not yet answered

Flag question

A slinky, essentially a spring with non-negligible mass, is in equilibrium when suspended from the top end. (Photo by R. C. Cross and M. S. Wheatland.)

Which statement best describes the motion immediately after the slinky is released?

- ○ The slinky remains stretched out. The whole slinky moves downwards together because gravity acts on all parts of the slinky.
- ○ The slinky compresses due to tension. All parts of the slinky move downwards, but the top portion moves down more quickly than the bottom portion.
- ○ The slinky compresses due to tension. The top and bottom portions of the slinky move towards the centre of mass, which remains stationary.
- ○ The slinky compresses due to tension. The top portion moves downwards and the bottom portion moves upwards, resulting in an overall downward motion of the centre of mass.
- ○ The slinky compresses due to tension. The top of the slinky moves downwards but the bottom of the slinky does not move.

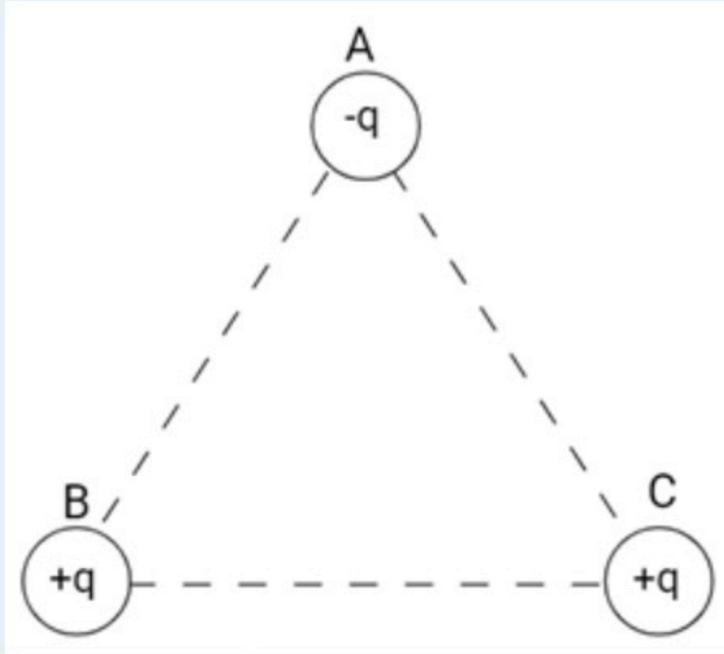
Question 28

Not yet answered

Flag question

Three charges, one negative and two positive, are held fixed at the corners of an equilateral triangle. The vertices of the triangle are labelled A, B and C respectively.

Which of the following statements is true?



- There exists a point within the triangle, which is not at the centre of the triangle, where the net electric field is zero.
- If the charge at B is no longer fixed and is released from rest, it will accelerate directly towards point A.
- If the charge at A is no longer fixed and is released from rest, it will pass through the midpoint of points B and C only once.
- The net electric field at the centre of the triangle is zero.
- If the charge at A is no longer fixed and is released from rest, it will pass through the midpoint of points B and C multiple times.

Question 29

Not yet answered

Flag question

Q_1 and Q_2, with charges +2e and -9e respectively, are held fixed at a distance 10.0 cm apart from each other.

Along the imaginary line that passes through them, for which of the following positions will **no work be done** in bringing a charge of +5e from infinitely far away to that position?

- 8.18 cm to the left of Q_2
- 1.08 cm to the left of Q_1
- None of the above
- 2.86 cm to the right of Q_2
- 3.20 cm to the right of Q_1

Question 30

Not yet answered

Flag question

An insulating thin spherical shell is uniformly charged, with total charge +Q. This shell has radius $4x$.

A proton is initially placed at point O, the centre of the sphere.

The proton is displaced to the **left** by a distance x, then displaced to the **right** by a distance $3x$.

The net displacement of the proton from O is thus $2x$ to the **right**.

Determine the net increase in the electric potential energy of the system.

- $\frac{Qe}{8\pi\epsilon_0 x}$
- $\frac{Qe}{6\pi\epsilon_0 x}$
- 0
- $\frac{Qe}{3\pi\epsilon_0 x}$
- \(\frac{Qe}{16 \pi \epsilon_0 x } \)

Question 31

Not yet answered

Flag question

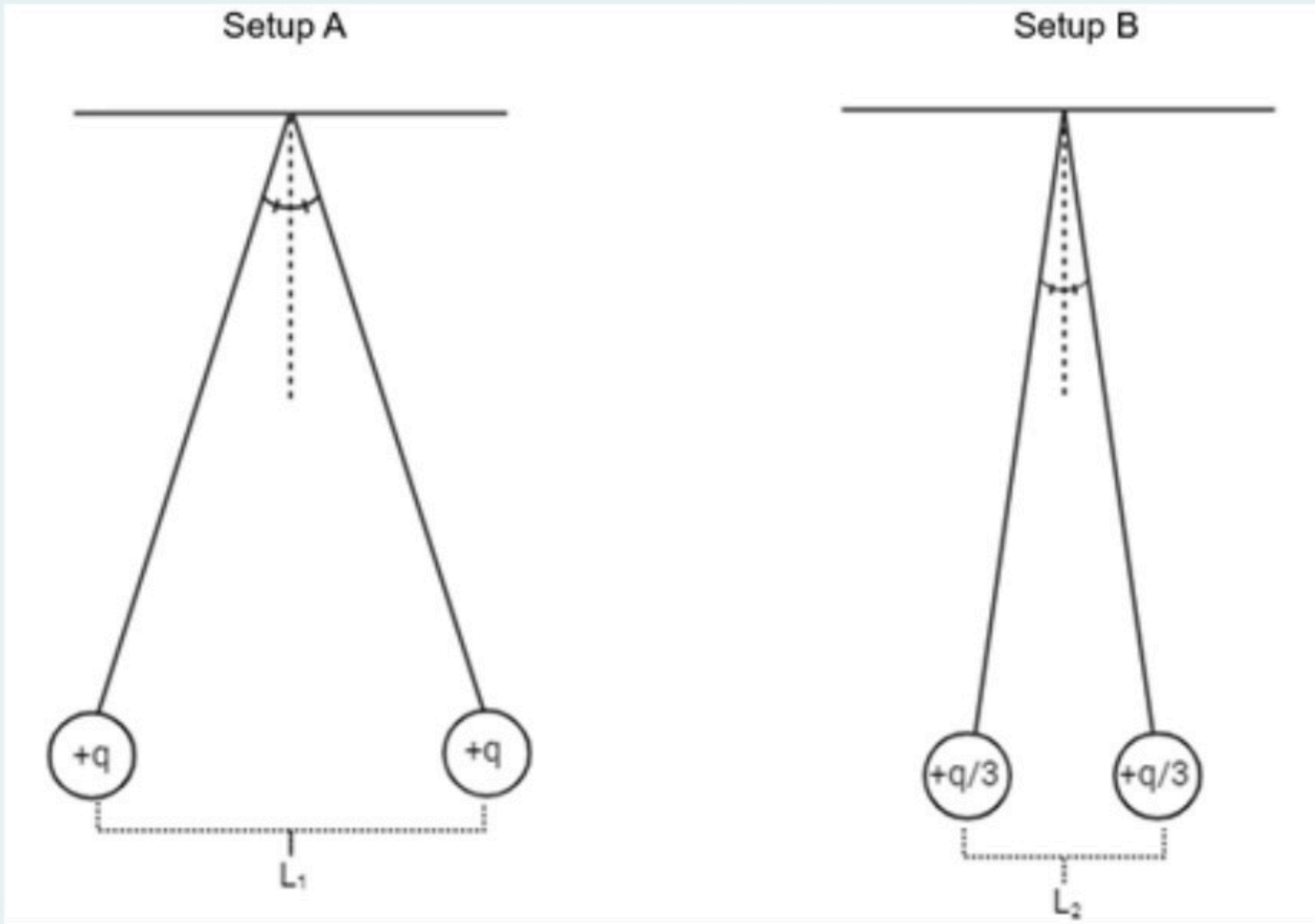
Time left (sorry)

Show

In setup A, two identical small spheres of the same mass and charge are … distance L_1 from each other when suspended by insulating strings that are very long and light.

In setup B, the same spheres are suspended from the same strings but now each have only one-third the charge, and settle into equilibrium at a distance L_2 from each other.

What is the ratio L_1/L_2?



- ○ $3\sqrt{2}$
- ○ 4
- ○ $\sqrt[3]{9}$
- ○ 3
- ○ $\sqrt[3]{4}$

Question 32

Not yet answered

Flag question

This image of a diver is taken from underwater (U.S. Navy photo by Mass Communication Specialist 1st Class Jayme Pastoric).

Suppose the illuminated circular region corresponds to an area of 10 m^2 at the surface.

From how far below the surface was this photo taken? Assume that the refractive index of water is 1.3 and that of air is 1.

- 1.8 m
- 1.5 m
- 2.1 m
- 10 m
- 3.2 m

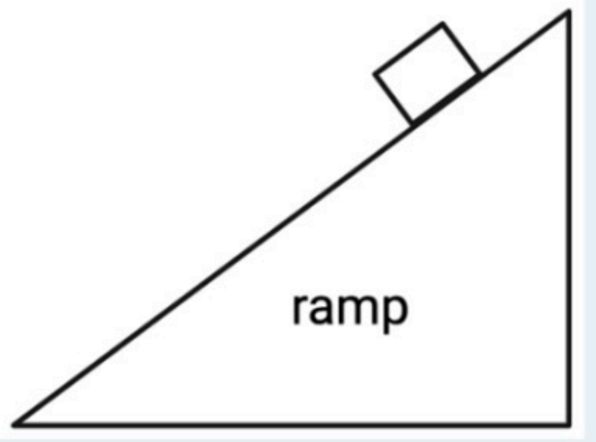
Question 33

Not yet answered

Flag question

Miss Bea has a collection of ramps made out of pure metal. The dimensions and angles are all identical and the inclined surfaces are all perfectly polished and smooth.

She takes out an extremely powerful and dangerous magnet. She says she will place the magnet at the top of each ramp, and asks you to predict which ramp will give the **shortest time** for the magnet to reach the ground.



The resistivities are given in the table below.

Material	**Resistivity ($n\Omega \cdot m$)**
Gold	24.4
Silver	15.9
Tungsten	56.0
Iron	100

- Iron
- All give the same time
- Tungsten
- Silver
- Gold

Question 34

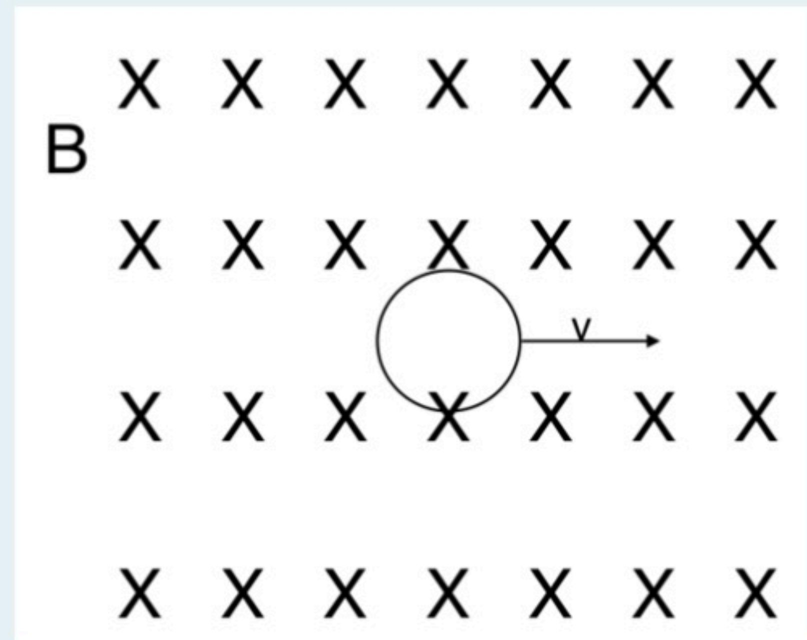
Not yet answered

Flag question

A circular coil of wire of radius *r* moves at constant velocity *v* through a uniform magnetic field as shown below.

The magnetic flux density is *B* and the magnetic field is perpendicular to the area of the coil and to the direction of the motion. The coil has electrical resistance *R*.

Determine the magnitude of the induced current in the coil, in terms of *B, v, r* and *R*.



- 0
- $\pi Bvr/R$
- $\pi Bvr^2/R$
- $2\pi Bvr/R$
- Bvr/R

Question 35

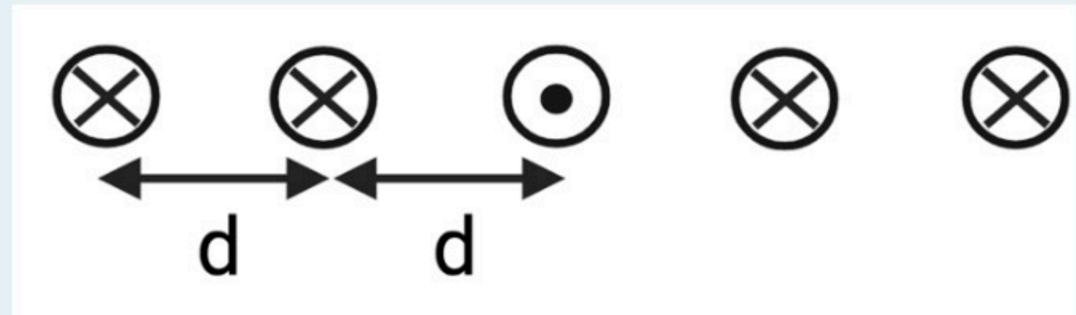
Not yet answered

Flag question

Five identical long wires are parallel and each carries a current I as shown in the diagram below.

The wires are evenly spaced out a distance *d* away from each other. The middle wire carries a current in the opposite direction to the rest of the wires.

Determine an expression for the magnitude of the force per unit length acting on the left-most current-carrying wire.



- ○ $\frac{13}{12} \frac{\mu_0 I^2}{\pi d}$
- ○ 0
- ○ $\frac{1}{2} \frac{\mu_0 I^2}{\pi d}$
- ○ $\frac{25}{12} \frac{\mu_0 I^2}{\pi d}$
- ○ \(\frac{13}{24} \frac{ \mu_0 I^2 }{ \pi d } \)

Question 36

Not yet answered

Flag question

In which of the following scenarios is there **no work done** by a non-contact force?

- Rain falls to the ground.
- A magnetic compass needle rotates towards the North pole.
- A capacitor is discharged.
- A moving proton is deflected by a magnetic field.
- Mercury orbits the Sun in an ellipse.

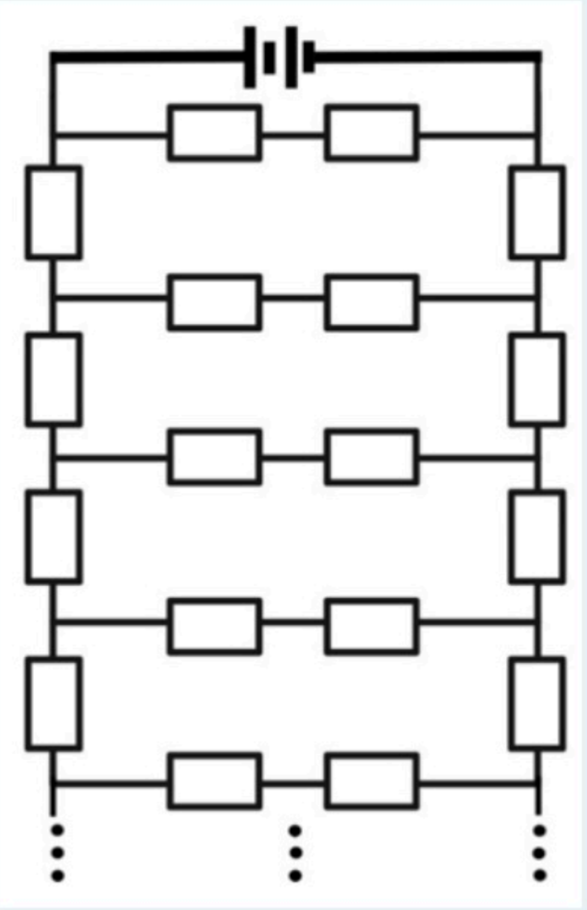
Question 37

Not yet answered

Flag question

Consider the following ideal arrangement of *infinitely* many identical resistors of resistance *R*.

Determine the effective resistance of this setup in terms of *R*.



- 1.240 R
- 1.230 R
- 1.234 R
- 1.236 R
- 1.233 R

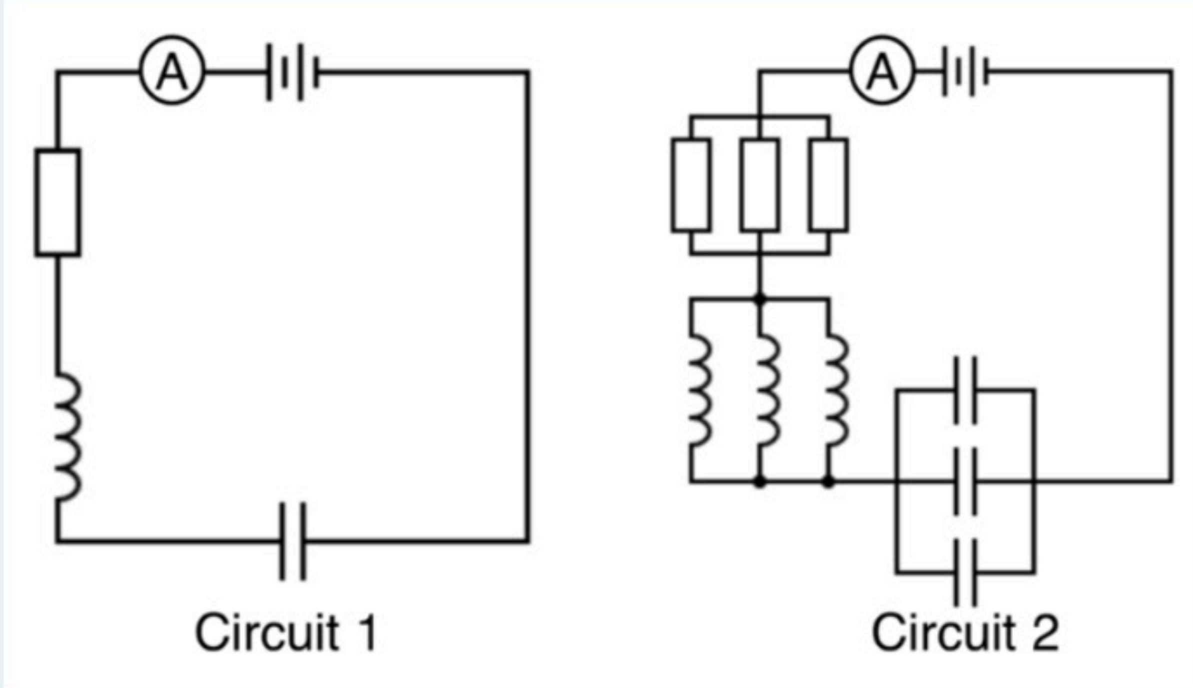
Question 38

Not yet answered

Flag question

A battery is used in each of the following circuits. Each circuit contains an ammeter, identical resistors of resistance *R*, identical inductors with inductance *L*, and identical capacitors with capacitance *C*.

Circuit 1 and Circuit 2 are shown below.



After a long time, the batteries in both circuits are removed, and the circuit is immediately closed by connecting a wire across where the battery used to be.

By observing the ammeter readings, we see that the current in each circuit oscillates with attenuated magnitude with a certain angular frequency ω.

Let the angular frequency for Circuit 1 be ω_1 and that for Circuit 2 be ω_2.

Determine the ratio ω_1/ω_2.

- $\sqrt{3}-1$
- $\sqrt{3}$
- 3
- 1
- $\frac{1}{\sqrt{3}}$

Question 39

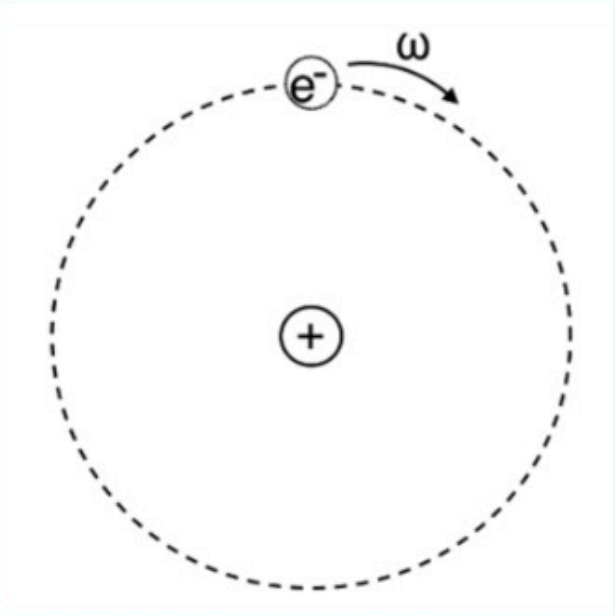
Not yet answered

Flag question

The Bohr model of an atom considers negatively-charged electrons moving in uniform circular motion around a positively-charged nucleus.

This model supposes that the orbiting electron does not radiate energy if its orbital angular momentum L is quantised, i.e., $L = nh/2\pi$, where n is a positive integer that depends on the energy state of the atom and h is Planck's constant.

Consider such a model for a hydrogen atom consisting of an electron orbiting a stationary proton.



In this model, the orbiting electron acts like a current loop and hence produces a magnetic field at the centre where the proton is.

According to this model, if the electron is de-excited from the n = 2 state to the n = 1 state, by what factor does the magnetic flux density at the nucleus increase by?

- 4
- 32
- 8
- 16
- 2

Question **40**

Not yet answered

Flag question

We can increase the temperature of an ideal gas under different conditions. Denote the heat capacity c_v for a constant-volume process and c_p for the constant-pressure heat capacity.

Which of these quantities has a higher value?

- c_v as the increased pressure means the gas hits the container walls more frequently, transferring more energy out of the system per unit time.
- Neither, since heat capacity only depends on the amount of ideal gas, which is kept constant in both scenarios.
- c_p as the gas loses heat to the surroundings faster as it expands.
- c_v as more energy is needed to increase the pressure of a gas in a fixed-volume container.
- c_p as more energy is needed to expand against the surroundings at constant pressure.

Question **41**

Not yet answered

Flag question

Your friend watches a video where a group of engineers cook a steak by slapping it over fifty thousand times rapidly, imparting kinetic energy into the particles of the steak.

Inspired by this, your friend wraps a steak in perfect insulation and brings it to the top of a mountain to increase the gravitational potential energy of the steak.

He claims that instead of increasing the kinetic energy, he will increase the potential energy in order to increase the internal energy of the steak, thus cooking the steak. Can this work?

- Yes. The gravitational force is weaker at higher altitudes, allowing the particles in the steak to vibrate faster. This results in an increase in the internal energy.
- Yes. Since internal energy is the sum of kinetic and potential energy, increasing the gravitational potential energy of the steak increases the internal energy of the steak.
- No. The internal energy of the steak only increases by a small amount during the climb up the mountain. He should use a rocket to go to higher altitudes for this to work.
- No. Changing the gravitational potential energy does not affect the internal energy of the steak.
- No. The perfect insulation prevents any change in the internal energy of the steak inside.

Question 42

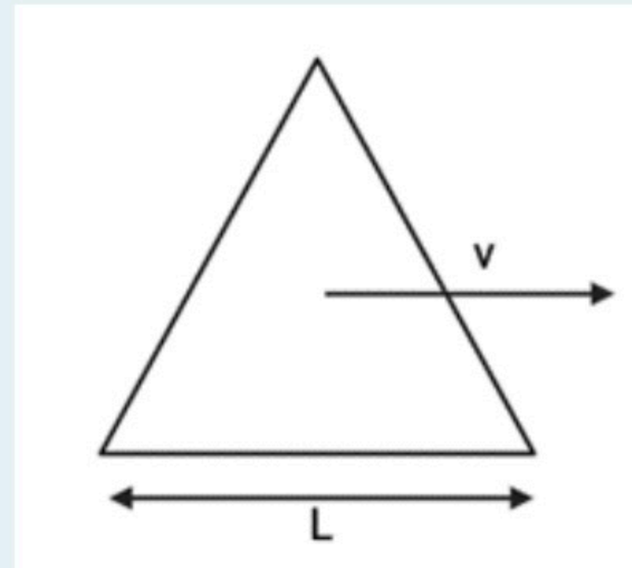
Not yet answered

Flag question

An object in the shape of an equilateral triangle of side length L in its rest frame is oriented as shown and travelling at a constant relativistic speed v towards the **right**, relative to an observer.

To the observer, what is the perimeter of the object?

In the answers below, $\gamma = 1/\sqrt{1-v^2/c^2}$ is the Lorentz factor.



- $\frac{L}{\gamma}(1+2\gamma)$
- $\frac{L}{\gamma}(1+\sqrt{1+3\gamma^2})$
- $\frac{L}{\gamma}(1+\sqrt{\gamma^2+3})$
- $\frac{L}{\gamma}(1+\frac{1}{2}\sqrt{1+3\gamma^2})$
- $\frac{3L}{\gamma}$