SINGAPORE JUNIOR PHYSICS OLYMPIAD 2022

INDIVIDUAL ROUND

24 May 2022 — 1500 – 1700

Time Allowed: **2 Hours**

INSTRUCTIONS

1. **Read the instructions on this page** but **DO NOT TURN the page** until you are told to do so by the invigilator.

2. This paper contains **50** multiple choice questions and **20** printed pages (including this cover page). Each question or incomplete statement is followed by four or five suggested answers or completions. **Select only the best** in each case and then **shade** the corresponding bubble on the answer sheet.

3. Use **2B pencil** only to shade the bubbles on the answer sheet, and make sure any stray markings are properly erased.

4. At the end of the test, please **submit** the **answer sheet** and the **question paper (attach all rough paper** used during the competition to the question paper). **Only** the **answer sheet** will be **marked**. Answers written anywhere else will not be marked.

5. **Fill in your index number in the space labelled as index number on the answer sheet now.** Write your **name** and **school** on the **answer sheet** and **question paper** now.

6. **Scientific calculators** are **allowed**. **Graphing** calculators are **not** allowed.

7. Answer **ONLY** questions you are confident of. Marks will be deducted for wrong answers. **A question left unanswered (blank) will score a higher mark than a wrong answer.**

8. A general data sheet is given in the following page. You may **detach the data sheet when the competition starts** so that you can refer to it easily.

Name: ______________________________

School: ______________________________

GENERAL DATA SHEET (unless otherwise stated in the problems)

Acceleration due to gravity at the surface of Earth, g = 9.80 $ms^{-2} = |g|$

Universal gravitational constant; G = $6.67\times10^{-11}\,kg^{-1}\,m^{3}\,s^{-2}$

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

Vacuum permittivity, $\varepsilon_0 = 8.85\times10^{-12}\ C^{2}\ N^{-1}m^{-2}$

Vacuum permeability, $\mu_0 = 4\pi\times10^{-7}$ T m A^{-1}

Atomic mass unit, $u = 1.66\times10^{-27}$ kg

Speed of light in vacuum, $c = 3.00\times10^{8}$ m s^{-1}

Speed of sound in air, v_s = 340 ms^{-1}

Charge of electron, $e = 1.60\times10^{-19}$ C

Planck's constant, $h = 6.63\times10^{-34}$ J s

Mass of the Earth, $M_E = 5.97\times10^{24}$ kg

Mass of electron, $m_e = 9.11\times10^{-31}$ kg = 0.000549u

Mass of proton, $m_p = 1.67\times10^{-27}$ kg = 1.007u

Mass of deuteron, $m_d = 3.34\times10^{-34}$ kg = 2.014u

Rest mass of alpha particle, $m_\alpha = 4.003\,u$

Boltzmann constant, $k = 1.38\times10^{-23}$ J K^{-1}

Avogadro's number, $N_A = 6.02\times10^{23}$ mol^{-1}

Standard atmosphere pressure, $P_0 = 1.01\times10^{5}$ Pa

Density of water, $\rho_w = 1000$ kg m^{-3}

Specific heat (capacity) of water, $c_w = 4.19\times10^{3}$ J $kg^{-1}\ K^{-1}$

Stefan-Boltzmann constant, $\sigma = 5.67\times10^{8}$ W $m^{-2}\ K^{-4}$

Radius of the sun, $R_S = 6.96\times10^{5}$ km

Radius of the earth, $R_E = 6.37\times10^{3}$ km

Distance between sun and earth, $d_{SE} = 1.5\times10^{8}$ km

Acceleration due to gravity at the sun's surface, $g_S = 28.02$ g

Temperature on the surface of the sun, $T_S = 5780$K

Remarks: For convenience, a block of mass *m* may be named as *m* and a charge of *q* may be named as *q*.

For questions 1-3.

The road is level, and a driver is driving at the speed limit of 50 km/h (i.e. 14 m/s) when he sees the traffic light ahead turns yellow. He does not want to go over the speed limit and wants to enter the intersection before the light turns red. Assume the magnitude of the car's maximum deceleration rate is 3.0 m/s^2 and the human reaction time is 1.0 s.

For questions 1 and 2: Can he avoid running the red light if the distance to the intersection and the duration of the yellow light are as follows:

1. 50 m and 3 s

a) Yes, by applying his brake and comes to a stop before the intersection only.

b) Yes, by continuing to drive at the speed limit only.

c) Yes, both a) and b) work.

d) No, both a) and b) do not work, and he will run the red light.

2. 40 m and 2 s

a) Yes, by continuing to drive at the speed limit only.

b) Yes, by applying his brake and comes to a stop before the intersection only.

c) Yes, both a) and b) work.

d) No, both a) and b) do not work, and he will run the red light.

3. What is the minimum duration for the yellow light so that the law-abiding driver can avoid running the red light, either by continuing to drive at the speed limit or by applying his brake and comes to a stop before the intersection, when he is approaching one?

a) 6.33s

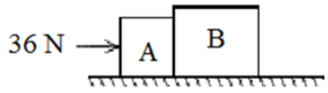
b) 2.33s

c) 4.33s

d) 3.33s

e) 5.33s

For questions 4 and 5.



Two blocks, A and B, of masses m_A = 4.0 kg and m_B = 20.0 kg are in contact and are moving with velocity 1.0 ms^{-1} on a horizontal floor. The 36-N constant force is then applied to A for 5 seconds as shown. Ignore friction.

4. After 5 seconds, the momentum (in kg $\cdot m \cdot s^{-1}$) of block B is ___.

a) 170

b) 204

c) 120

d) 150

e) 240

5. After 5 seconds, the net work done (in J) on the block A is ___.

a) 712.5

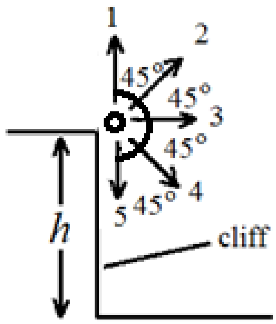
b) 142.5

c) 663

d) 112.5

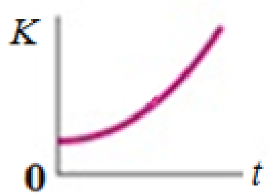
e) 855

For questions 6 and 7.



A ball is launched with a non-zero velocity v_0 in one of the five directions from the edge of a cliff. Direction 1 is vertically up and direction 5 is vertically down, and direction 3 is rightward horizontally while directions 2 (4) are mid-way between 1 and 3 (3 and 5).

The block's kinetic energy K varies with time as shown. Note that the gradient of the K-t graph is **zero** at t = 0.



6. Which is the direction of the initial velocity of the ball?

a) 4

b) 2

c) 3

d) 1

e) 5

7. Ignoring air resistance, the time taken for the ball to land at the bottom of the cliff is ___.

a) $\frac{v_0}{g}\left(1+\sqrt{1+\frac{2gh}{v_0^2}}\right)$

b) $\frac{v_0}{\sqrt{2}g}\left(1+\sqrt{1+\frac{4gh}{v_0^2}}\right)$

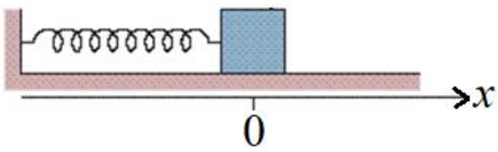
c) $\sqrt{2gh}$

d) $\frac{v_0}{\sqrt{2}g}\left(\sqrt{1+\frac{4gh}{v_0^2}}-1\right)$

e) $\frac{v_0}{g}\left(\sqrt{1+\frac{2gh}{v_0^2}}-1\right)$

For questions 8 and 9.

A spring that obeys Hooke's law and a block of mass 2.0 kg are set up as shown. When the block is at x = 0, the spring is at its natural length. The block is pulled out to x = 5.0 cm, and a force of magnitude 10 N is required to hold it there. Then the block is released. Ignore friction.



8. How much is the work done by the spring on the block to move it from x = 5.0 cm to x = –3.0 cm?

a) 0.16J

b) -0.16J

c) 0.08J

d) -0.08J

e) cannot be determined as the spring constant is not given

9. How much time does the spring take to move block from x = 5.0 cm to x = –3.0 cm?

a) 0.11s

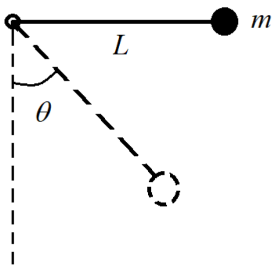
b) 0.093s

c) 0.22s

d) 12.7s

e) 2.2s

Questions 10 and 11.



10. A simple pendulum, consisting of a string tied to a frictionless fixed pivot at one end and a bob of mass *m* at the other end, is gently released from the horizontal position (i.e. $\theta = 90^0$) as shown.

After the release, the tension of the string is given by ___.

a) $3mg\cos\theta$

b) $3mg\sin\theta$

c) $mg\cos\theta$

d) $mg\sin\theta$

e) $4mg\cos\theta$

11. In order for the string not to break during the swing, it must be able to withstand a tension of ___.

a) 2 *mg*

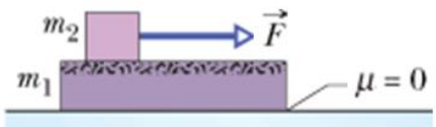
b) 4 *mg*

c) 8 *mg*

d) 6 *mg*

e) 3 *mg*

For questions 12 and 13



12. A slab of mass m_1 rests on a frictionless floor, and a block of mass m_2 rests on top of the slab. Between the block and slab, the coefficient of static friction is μ_s and the coefficient of kinetic friction is μ_k. A horizontal force of magnitude *F* begins to pull directly on the block, as shown. The condition for the two masses to move as one piece is, ____, where $M = m_1 + m_2$.

a) $\mu_s \le \frac{m_1}{m_2}\frac{F}{Mg}$

b) $\mu_s \le \frac{m_2}{m_1}\frac{F}{Mg}$

c) $\mu_s \ge \frac{m_1}{m_2}\frac{F}{Mg}$

d) $\mu_s \ge \frac{m_2}{m_1}\frac{F}{Mg}$

e) The two masses will always move as one piece since there is friction between them and no friction between the slab and the floor.

Hint: The kinetic friction on an object is given by $\mu_k N$ where *N* is the normal force on the object. The maximum static friction on an object is given by $\mu_s N$.

13. Suppose m_1= 50 kg and m_2 = 20 kg, $\mu_s = 0.55$, $\mu_k = 0.40$ and F = 140 N, what is the resulting acceleration (in m·s^{-2}) of the block? Take g = 10 N/kg.

a) 7.0

b) 3.0

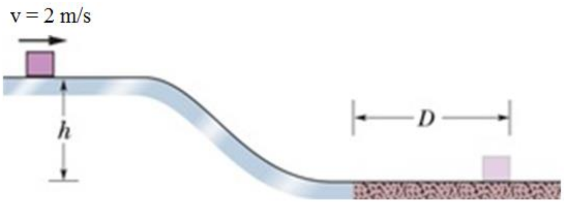
c) 3.3

d) 1.6

e) 2.0

For questions 14 – 16

A block of mass *m* slides with an initial velocity of 2 m/s along a horizontal track that descends through distance *h*. The track is frictionless except for the lower section. There the block slides to a stop in a certain distance *D* because of friction.



14. If *h* is halved, D ____.

a) will be halved

b) will be unchanged

c) will be doubled

d) will be tripled

e) cannot be determined due to insufficient information

15. If *m* is doubled, D ____.

a) will be halved

b) will be unchanged

c) will be doubled

d) will be tripled

e) cannot be determined due to insufficient information

16. If m is doubled, the total thermal energy generated due to friction as the block slides to a stop ______.

a) is halved

b) is unchanged

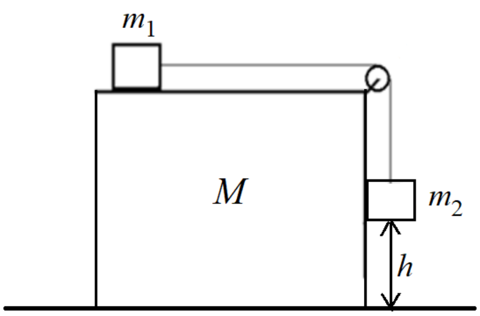
c) is doubled

d) is tripled

e) cannot be determined due to insufficient information

For questions 17- 21

A block of mass m_1 is placed on top of a block of mass M. Holding block m_1 stationary, it is joined by a string which passes over the pulley to a block of mass m_2 hanging by the side of (and in contact with) block M, and is at height h above the floor. We will assume that the string is inextensible and massless, and all the contacts between objects in relative motion are frictionless. Furthermore, we will be concerned with the part of the motion before m_1 reaches the pulley.



For questions 17 and 18, assume that M is fixed to the floor, and the pulley is massless. After m_1 is released from rest, both m_1 and m_2 move smoothly with a constant acceleration and the string remains taut.

17. What is the acceleration of blocks m_1 and m_2?

a) $\frac{m_1}{m_1+m_2}g$

b) $\frac{m_2}{m_1+m_2}g$

c) g

d) $\frac{m_1+m_2}{m_1}g$

e) $\frac{m_1+m_2}{m_2}g$

18. What is the time taken for m_2 to reach the floor after m_1 is released from rest?

a) $\sqrt{\frac{2h(m_1+m_2)}{m_1 g}}$

b) $\sqrt{\frac{2h(m_1+m_2)}{m_2 g}}$

c) $\sqrt{\frac{2h}{g}}$

d) $\sqrt{\frac{2h\, m_1}{(m_1+m_2)g}}$

e) $\sqrt{\frac{2h\, m_2}{(m_1+m_2)g}}$

For questions 19 and 20, all assumptions remain except that M is no longer fixed to the floor but can move without friction on the floor.

19. By considering the motion (or non-motion) of the center of mass and/or otherwise, when m_2 reaches the floor, what is the distance moved by M ? State in which direction if it has moved.

a) 0

b) $\frac{m_1 h}{M+m_1+m_2}$, leftward

c) $\frac{m_1 h}{M+m_1+m_2}$, rightward

d) $\frac{m_1 h}{M+m_2}$, leftward

e) $\frac{m_1 h}{M+m_2}$, rightward

20. By applying a constant rightward force on M, both m_1 and m_2 can remain at rest relative to M without having to hold them. This force is ___.

a) $\frac{m_1}{(M+m_1+m_2)m_2} g$

b) $\frac{m_2}{(M+m_1+m_2)m_1} g$

c) $\frac{(M+m_1+m_2)m_1}{m_2} g$

d) $\frac{(M+m_1+m_2)m_2}{m_1} g$

e) none of the above

21. For this question, assume that M is fixed to the floor, and the mass and radius of the pulley is m_3 and R, respectively. What is the acceleration of blocks m_1 and m_2? Hint: Take the moment of inertia of the pulley as $I = \frac{1}{2}m_3R^2$

a) $\frac{m_1}{m_1+m_2+\frac{m_3}{2}}g$

b) $\frac{m_2}{m_1+m_2+\frac{m_3}{2}}g$

c) $\left(1 - \frac{m_3}{2(m_1+m_2)}\right)g$

d) $\frac{m_1+m_2+\frac{m_3}{2}}{m_1}g$

e) $\frac{m_1+m_2+\frac{m_3}{2}}{m_2}g$

22. Water is flowing vertically downward from a tap at a moderate speed. As it falls, the water column's diameter ___.

a) decreases

b) remains unchanged

c) increases

d) decreases in Northern Hemisphere but increases in Southern Hemisphere

e) increases in Northern Hemisphere but decreases in Southern Hemisphere

23. Water is dripping drop by drop from a tap into a bowl placed on a nearly horizontal surface as shown. The bowl is just a couple of cm below the tap. Eventually the bowl is filled and ___.

a) water will run off the edge of the bowl drop by drop in succession.

b) water will run off the edge of the bowl in a narrow stream for a little while and stop for a little while, and this pattern is repeated.

c) water will run off the edge of the bowl in a narrow stream continuously.

d) water will run off the edge of the bowl drop by drop in succession for several drops, then will stop for a little while, and this pattern is repeated.

24. How much weight can a Styrofoam cup of volume 200 cm^3 carry before it sinks in water? Assume the weight of Styrofoam is negligible and take the density of water as 1 $g \cdot cm^{-3}$.

a) 0.2N

b) 5N

c) 20N

d) 1N

e) 2N

For questions 25 and 26

The specific gravity of a substance is defined as the ratio of the density of the substance to that of pure water. The specific gravity of pure ice is 0.92, and that of seawater is 1.03.

25. What percentage of an iceberg made up of pure ice is above the surface of the seawater?

a) 9%

b) 8%

c) 12%

d) 11%

e) 10%

26. A piece of pure ice is gently placed into a measuring cylinder containing seawater. The ice floats and the seawater level is noted. After the ice has melted, the seawater level will ____.

a) rise

b) stay the same

c) drop

d) depend on the amount of the pure ice, i.e. can be either a) or b) or c)

27. The solar irradiance (solar power per unit area) at the ground level is approximately 1000 W/m^2 when the sun is directly overhead. A solar panel has an efficiency of 20%. Neglecting any differences in atmospheric losses, when the sun is 40^o above the horizon the power output (in W/m^2) from the solar panel placed flat at ground level is approximately ___.

a) 130

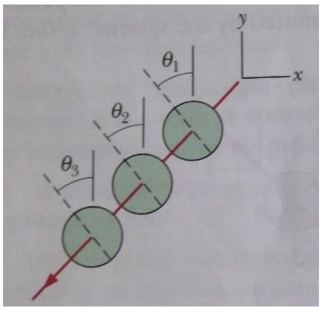
b) 170

c) 200

d) 150

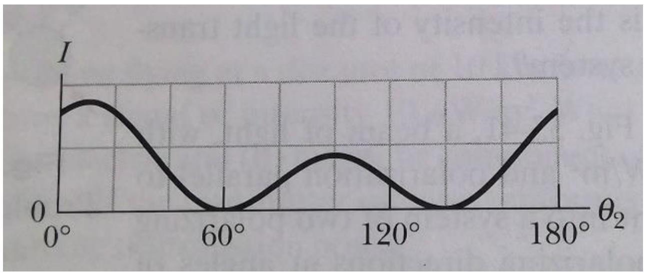
e) cannot be estimated

For questions 28 and 29.



Unpolarized light is sent into a system of three polarizing sheets whose angles of polarizing directions are measured counter-clockwise from the positive y-axis. The angles θ_1 and θ_3 are fixed, but θ_2 can be varied. (Remark: The angles in the figure are not drawn to scale).

The intensity of the light emerging from sheet 3 as a function of θ_2 is as shown below:



28. Which of the following is a possible set of values for θ_1 and θ_3?

a) $\theta_1 = 60^o$, $\theta_3 = 90^o$

b) $\theta_1 = 60^o$, $\theta_3 = 150^o$

c) $\theta_1 = 150^o$, $\theta_3 = 50^o$

d) $\theta_1 = 150^o$, $\theta_3 = 60^o$

e) none of the above

29. What percentage of the light's initial intensity is transmitted by the three-sheet system when θ_2 is 100°?

a) 8.5%

b) 17%

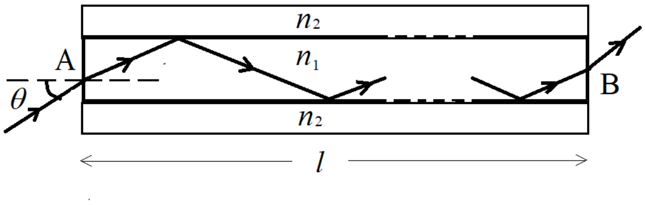
c) 12%

d) 41%

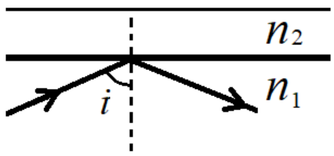
e) 20.5%

For questions 30-34

The figure below illustrates the basic idea on the transmission of data encoded in light signal via an optical fiber of length l, which may be taken as comprised of three thin layers of material where the interfaces between the layers are smooth and flat. The middle layer is a transparent material of refractive index n_1 while the refractive index of the top and bottom layers is n_2.



For questions 30 and 31: As illustrated by the figure here, consider the incident of light at the interface for light coming from the layer of refractive index n_1.



30. For total internal reflection at the interface to occur, it is necessary that ____.

a) $n_2 < n_1$

b) $n_2 = n_1$

c) $n_2 > n_1$

d) $n_1^2 + n_2^2 = 1$

31. If the angle of incidence i is greater than a certain critical angle, total internal reflection occurs. The sine of the critical angle equals ____.

a) $\frac{n_1^2}{n_2^2}$

b) $\frac{n_2^2}{n_1^2}$

c) $\frac{n_1}{c}$

d) $\frac{n_1}{n_2}$

e) $\frac{n_2}{n_1}$

For questions 32 - 34: When light is incident at an angle θ at the middle of layer A, light undergoes refraction and travels to the top interface. Under a certain condition, the light not only undergoes total internal reflection at the top interface, but travels to the bottom interface where it again undergoes total internal reflection, and this pattern is repeated until the light exits from the optical fibre at B. Assume that the optical fibre is surrounded by air that has refractive index = 1.

32. The condition is ____.

a) $\sin\theta < n_2 - n_1$

b) $\sin\theta < n_1 - n_2$

c) $\sin\theta < \sqrt{n_2^2 - n_1^2}$

d) $\sin\theta < \sqrt{n_1^2 - n_2^2}$

33. The incident angle θ can be any value between 0 ^{o} and 90 ^{o} if the following further condition holds, namely ____.

a) $n_2 - n_1 > 1$

b) $n_1 - n_2 > 1$

c) $n_2^2 - n_1^2 > 1$

d) $n_1^2 - n_2^2 > 1$

34. The time taken for the light to travel from A to B is ____.

a) $\frac{l}{c}$

b) $\frac{ln_1n_2}{c\sqrt{n_1n_2 - sin\theta}}$

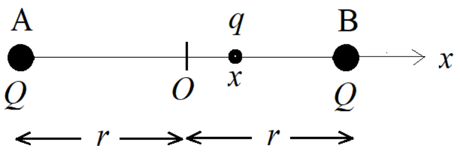
c) $\frac{ln_2}{c\sqrt{n_2 - sin\theta}}$

d) $\frac{ln_1^2}{c\sqrt{n_1^2 - sin^2\theta}}$

e) $\frac{ln_2^2}{c\sqrt{n_2^2 - sin^2\theta}}$

For questions 35 and 36

Two fixed positive point charges Q are $2r$ apart, one at A and one at B. Let the mid-point between them be the origin of the x-axis. A third positive charge q of mass m is placed at a point labelled x, which is slightly to the right of the origin. Let k denote $\frac{1}{4\pi\varepsilon_o}$.



(Hint: You may find the identity $(a^2 - b^2) = (a - b)(a + b)$ helpful. The term x^2/r^2 is very small compared to 1, and so may be ignored, i.e. $1 \pm \frac{x^2}{r^2}$ can just be approximated as 1.)

35. The net force on q at the point x is given by _____.

a) $-\frac{kQq}{rx}$

b) $\frac{kQq}{rx}$

c) $-\frac{kQq}{r^3}x$

d) $\frac{kQq}{r^3}x$

e) $-\frac{4kQq}{r^3}x$

36. The time taken for the charge q to move to O is ___.

a) $\frac{\pi r}{4}\sqrt{\frac{mr}{kQq}}$

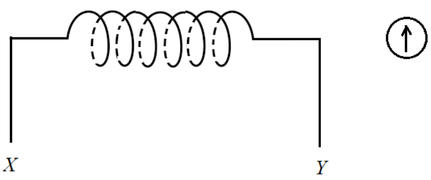
b) $\frac{\pi r}{2}\sqrt{\frac{mr}{kQq}}$

c) $\frac{\pi}{4r}\sqrt{\frac{kQq}{mr}}$

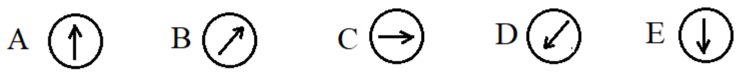
d) $\frac{\pi}{2r}\sqrt{\frac{kQq}{mr}}$

e) $\frac{\pi}{2}\sqrt{\frac{mr}{kQq}}x$

37. A compass is placed near a solenoid. When there is no current in the solenoid, the compass needle points due north as shown.



When there is current from X to Y, the magnetic field of the solenoid at the compass is equal in magnitude to the Earth's magnetic field at that point. In which direction does the compass set?



38. You push a bar magnet with its north pole away from you toward a loop of conducting wire in front of you. The plane containing the loop is perpendicular to the magnet. As the north pole approaches the loop, the current in the loop is ___.

a) clockwise then counterclockwise

b) counterclockwise then clockwise

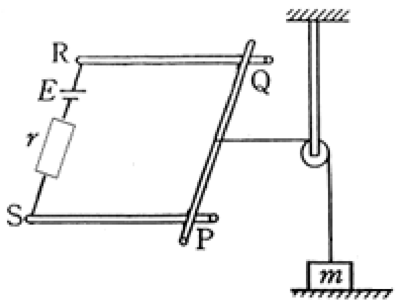
c) zero

d) clockwise

e) counterclockwise

For questions 39 - 41

As shown in the figure, a metal rod is placed on two fixed conducting rails at points P and Q. R and S are the end points of the rails, so $PQRS$ is a square circuit of side l on a horizontal plane. Between RS is a battery of emf E, a resistance r and a switch (not shown). A mass m resting on the floor is connected to the rod at the mid-point of PQ by a horizontal string which passes through a pulley and runs parallel to the rails.



Neglect the resistances of the rails, the rod and the contacts as well as the internal resistance of the battery. Neglect also the mass of the rod and string, and the friction between parts in relative motion. Take $g = 10$ m/s^2, $m = 0.1$ kg, $l = 1.0$ m, $E = 20.0$ V, $r = 100\ \Omega$.

Now, we want to lift the mass by passing as small as possible a magnetic field B through the circuit.

39. In which direction should the magnetic field point?

a) any direction will do

b) horizontal leftward

c) horizontal rightward

d) vertically downward

e) vertically upward

40. Let the magnetic field be increased from zero at a constant rate so that the mass *m* starts to move up at 1 second. The value of the magnetic field at this time is ___.

a) 3T

b) 2T

c) 4T

d) 10T

e) 5T

41. If the rate of increase of the magnetic field *B* approaches zero, the magnitude of the magnetic field required approaches _____.

a) 3T

b) 2T

c) 4T

d) 10T

e) 5T

42. A hole is cut from a sheet metal. When the temperature of the sheet metal increases, the hole _____.

a) gets smaller

b) remains the same size

c) gets bigger

d) can be a) or b) or c) depending on the shape of the hole.

43. An iron ring is to fit tightly on a cylindrical iron rod. At 25 ^oC, the diameter of the rod is 6.492 cm and the inside diameter of the ring is 6.480 cm. To slip over the rod, the ring must be larger than the rod diameter by about 0.008 cm. To what temperature must the ring be heated? Take the coefficient of linear expansion of iron $= 12 \times 10^{-6}$.

a) 230 ^oC

b) 257 ^oC

c) 282 ^oC

d) 303 ^oC

e) 448 ^oC

44. It is recommended to use water of approximately 80 ^oC to make green tea. This can be prepared by mixing x litres of water at room temperature (28 ^oC) with every litre of water at 100 ^oC. Neglecting the small changes in the density of water as its temperature changes, the value of x ____.

a) is 0.5

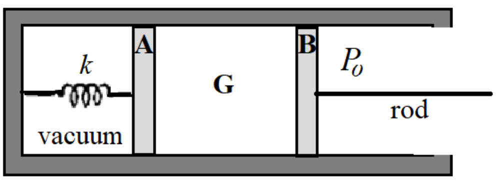
b) is 0.4

c) is 0.2

d) is 2.6

e) cannot be determined

Questions 45 - 50



The figure shows the interior of an open-at-one-end cylinder of cross-sectional area S. The cylinder is fixed and is partitioned into three sections by two smoothly movable partitions A and B of negligible mass. The leftmost section is a vacuum, the middle section is filled with an ideal gas G and the rightmost section is open, and therefore subject to the atmospheric pressure P_0. A massless spring of spring constant k connects partition A to the base of cylinder and a massless rod is connected to partition B. The cylinder and the partitions are made of heat-insulating materials.

Initially the system is at equilibrium with partitions A and B being stationary, G's temperature and volume are T_0 and V_0 respectively, and the compression of the spring is x_0.

45. The compression x_0 of the spring is given by ____.

a) $\frac{P_0 S}{3k}$

b) $\frac{P_0 S}{2k}$

c) $\frac{P_0 S}{k}$

d) $\frac{2P_0 S}{k}$

e) $\frac{3P_0 S}{k}$

Now the ideal gas G is heated up slowly (say by a heater inserted into the middle section while keeping the heat insulation) to temperature T_1 while you are keeping partition B fixed in position by holding and exerting a force on the rod. The spring is observed to have compressed by x_1, i.e. its length now is shorter than its natural length by x_1.

46. The change in the internal energy of G (namely its internal energy when at T_1 minus its internal energy when at T_0) is given by ___.

a) $nR(T_1 - T_0)$

b) $\frac{3}{2}nR(T_1 - T_0)$

c) $\frac{1}{2}k(x_1^2 - x_0^2)$

d) $nR(T_1 - T_0) + \frac{1}{2}k(x_1^2 - x_0^2)$

e) $\frac{3}{2}nR(T_1 - T_0) + \frac{1}{2}k(x_1^2 - x_0^2)$

47. The amount of heat transferred to the ideal gas G is given by ___.

a) $nR(T_1 - T_0)$

b) $\frac{3}{2}nR(T_1 - T_0)$

c) $\frac{1}{2}k(x_1^2 - x_0^2)$

d) $nR(T_1 - T_0) + \frac{1}{2}k(x_1^2 - x_0^2)$

e) $\frac{3}{2}nR(T_1 - T_0) + \frac{1}{2}k(x_1^2 - x_0^2)$

48. After the ideal gas G reaches temperature T_1, the heating is turned off. Partition B slowly moves a distance d to the right and G's temperature reduces to T_2 as you slowly reduce your force exerted on the rod to zero. What is the work done by G on your hand during this time as B and your hand moves the distance d ?

Let I. $nR(T_1 - T_2)$, II. $\frac{3}{2}nR(T_1 - T_2)$, III. $\frac{1}{2}k(x_1^2 - x_0^2)$, and IV. P_0Sd

a) I+III - IV

b) I+III + IV

c) II - IV

d) II +III - IV

e) IV

49. Next, you let go of your hand that was holding the rod and heat is removed from G slowly by some appropriate means until G returns to its initial state of pressure P_o and volume V_o. How much heat is removed?

Let I. $nR(T_2 - T_0)$, II. $\frac{3}{2}nR(T_2 - T_0)$, III. P_0Sd

a) I - III

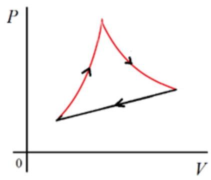
b) I + III

c) II - III

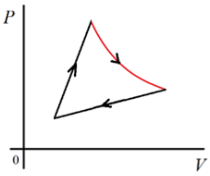
d) II +III

e) IV

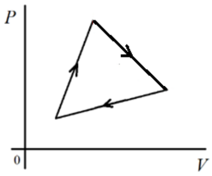
50. As described between questions 45 to 49, the complete cycle of processes that the ideal gas G undergoes, starting from and returning to the pressure P_o and volume V_o, is described by which of the following graphs?



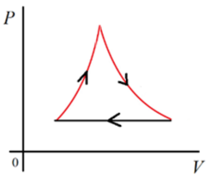
a)



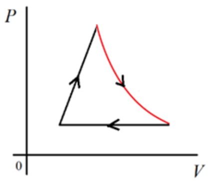
b)



c)



d)



e)