2024 Preliminary Examination H1 Physics Paper 1 Suggested Solution

1	**D**	**6**	**B**	**11**	**D**	**16**	**D**	**21**	**B**	**26**	**A**
2	**B**	**7**	**C**	**12**	**A**	**17**	**D**	**22**	**A**	**27**	**B**
3	**C**	**8**	**D**	**13**	**B**	**18**	**D**	**23**	**B**	**28**	**A**
4	**C**	**9**	**B**	**14**	**D**	**19**	**A**	**24**	**A**	**29**	**A**
5	**D**	**10**	**D**	**15**	**A**	**20**	**B**	**25**	**B**	**30**	**C**

1. Which one of the following estimates is unrealistic?

A The potential energy of a man at the top of Bukit Timah Hill is 100 kJ.
B The volume of air in a classroom is 150 m^3.
C The mass of an apple is 100 g
D The average temperature of fire is 300 K.

Ans: D

A: Height of Bukit Timah Hill = 160 m,
potential energy of man = mgh = (60)(9.81)(160)
= 94 kJ

B: Volume of air in classroom = volume of classroom
= 7 x 8 x 3
= 147 m^3

C: 100 g for an apple is quite reasonable right…

D: 300 K is 27 ^{o}C, so is unrealistic for the temperature for fire.

2. The rate of energy transfer, H through a conducting slab is found experimentally to be given by

$$H = kA\frac{\Delta T}{l}$$

where the proportionality constant k is the thermal conductivity of the material, A is the cross-sectional area of the slab, l is the length of the slab and ΔT is the temperature difference at opposite faces of the slab. Which of the following are the base units of k?

A kg m^2 s^{-2} K^{-1}
B kg m s^{-3} K^{-1}
C kg m s^{-2} K^{-1}
D unitless

Ans: B

$$k = \frac{Hl}{A\Delta T}$$

$$\text{units of k} = \frac{(\text{J s}^{-1})(\text{m})}{\text{m}^2\ \text{K}} = \frac{(\text{kg m}^3\ \text{s}^{-3})}{\text{m}^2\ \text{K}} = \text{kg m s}^{-3}\ \text{K}^{-1}$$

3. Two projectiles are fired from a gun as shown in Fig. 3.

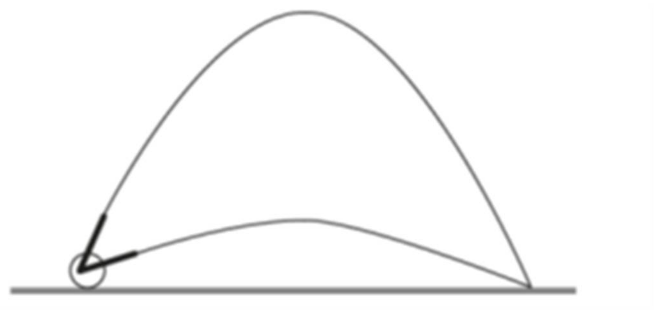


Fig. 3

The first projectile leaves the gun at a velocity of 140 m s^{-1} at an angle to the horizontal of 75°. The second projectile is fired from the gun at the same position with the same speed but at an angle of 15°. How much time later should the second projectile be fired so that both projectiles land at the same point on the ground at the same time? Ignore the effects of air resistance.

A 10 s **B** 15 s **C** 20 s **D** 30 s

Ans: C

Vertically, from $v_y = u_y + a_y t$,

Time to reach max. height, $t = \dfrac{u\sin\theta}{g}$

Time of flight, $2t = \dfrac{2u\sin\theta}{g}$

1st projectile, time of flight = $\dfrac{2(140)\sin 75}{9.81} = 27.6$ s

2nd projectile, time of flight = $\dfrac{2(140)\sin 15}{9.81} = 7.39$ s

Time difference = 27.6 - 7.39 = 20.2 s

4. The velocity- time graph of a particle moving in a straight line is shown in Fig. 4

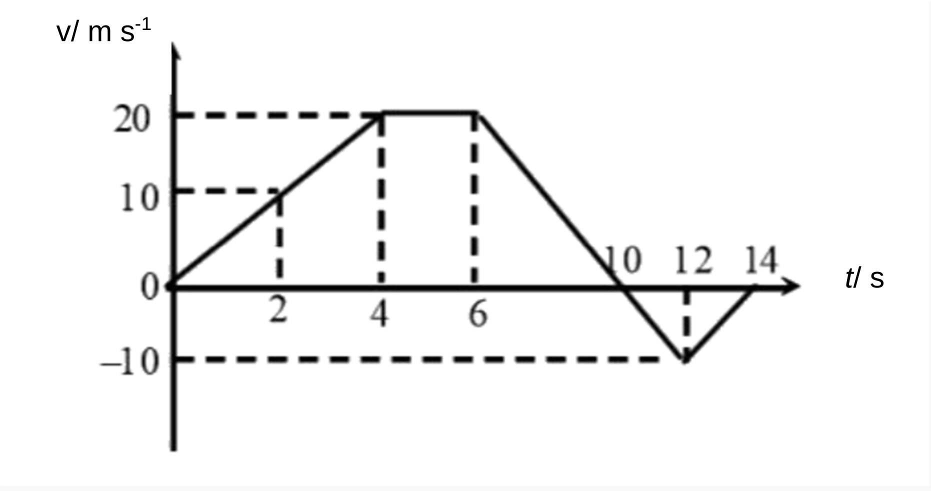


Fig. 4

What are the average speed and velocity of the particle between time t = 0 and t = 14 s?

	Average speed / m s^{-1}	Average velocity / m s^{-1}
A	7.1	7.1
B	7.1	10
C	10	7.1
D	10	10

Ans: C

Displacement = Area under velocity-time graph

$$= \frac{1}{2}(2+10)(20) - \frac{1}{2}(10)(4)$$

$$= 120 - 20$$

$$= 100 \text{ m}$$

Above time axis: positive displacement
Below time axis: negative displacement

$$\text{Average velocity} = \frac{\text{displacement}}{\text{time}} = \frac{100}{14}$$

$$= 7.1 \text{ m s}^{-1}$$

Distance = Area under velocity-time graph

$$= \frac{1}{2}(2+10)(20) + \frac{1}{2}(10)(4)$$

$$= 120 + 20$$

$$= 140 \text{ m}$$

Distance is a scalar and has no direction. So areas above and below time axis are considered as positive.

$$\text{Average velocity} = \frac{\text{displacement}}{\text{time}} = \frac{140}{14}$$

$$= 10 \text{ m s}^{-1}$$

5. An aeroplane, flying in a straight line at a constant height of 500 m with a speed of 200 m s^{-1}, drops an object. The object takes a time *t* to reach the ground and travels a horizontal distance *d* in doing so. Ignoring air resistance, which one of the following gives the values of *t* and *d*?

	t /s	*d* /km
A	25	10
B	25	5
C	10	5
D	10	2

Ans: D

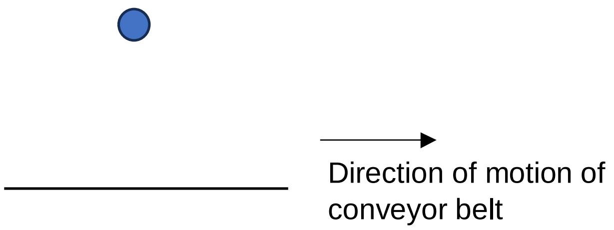
Vertically, $s_y = u_u t + \frac{1}{2} a_y t^2$

$$500 = \frac{1}{2} g t^2$$

$$t = \sqrt{\frac{500 \times 2}{9.81}} = 10 \text{ s}$$

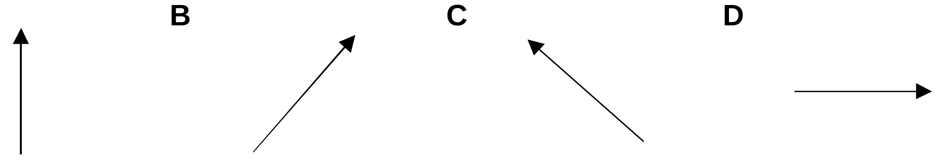
Horizontally, $d = u_x t = 200\ t = (200)(10) = 2 \text{ km}$

6. A ball falls vertically and bounces on a moving conveyor belt.



What is the direction of the resultant force due to the conveyor belt acting on the ball?

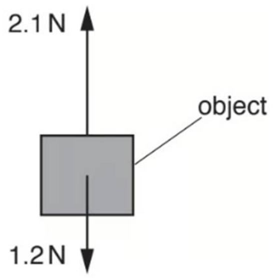
A **B** **C** **D**



Ans: B

When the ball bounces on the conveyor belt, there is an upward force on the ball by the conveyor belt to cause it to rebound upwards and there is a forward force in the same direction of motion of the conveyor belt to cause it to move forward. The resultant of these two forces is diagonally upwards towards the right.

7. The diagram shows two opposite vertical forces of magnitude 1.2 N and 2.1 N acting on an object.



Which of the following statements is wrong?

A The magnitude of the resultant force is 0.9 N.

B The object is accelerating and moving up.

C The object is decelerating and moving up.

D The object is decelerating and moving down.

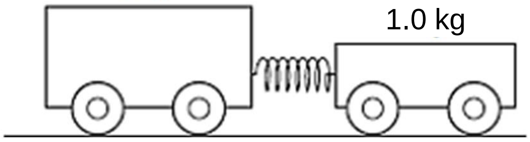
Ans: C

Option A: The magnitude of the resultant force is 2.1 – 1.2 = 0.9 N
Option B: The resultant force is 0.9 N upwards since the force exerted on it upwards is larger than the force exerted on it downwards. If object is moving upwards in the same direction of the resultant force, it will be accelerating.

Option C: If object is moving upwards in the same direction of the resultant force, it will be accelerating and not decelerating.

Option D: If object is moving downwards in the opposite direction of the resultant force, it will be decelerating.

8. Two trolleys are placed together on a horizontal runway with a compressed spring between them.



When they are released, the 2.0 kg trolley moves to the left at 2.0 m s^{-1}.

How much energy was stored in the spring?

A 4.0 J **B** 6.0 J **C** 8.0 J **D** 12 J

Ans: D

Find final speed v of the 1.0 kg trolley:

Taking → as +ve and using conservation of momentum,

Total initial momentum = total final momentum

$$0 = 2.0(-2.0) + 1.0(v)$$

$$v = 4.0 \text{ m s}^{-1}$$

Energy stored in spring is converted to gain in KE of trolleys.

Energy stored in spring = $\frac{1}{2}(2.0)(2.0)^2 + \frac{1}{2}(1.0)(4.0)^2 = 12\text{ J}$

9. A steel spring was stretched to a length of 58 cm when a 30 N weight was hung from it. The same spring was stretched to a length of 72 cm when a 51 N weight was hung from it.

What was the original length of the spring?

A 15 cm **B** 38 cm **C** 44 cm **D** 61 cm

Ans: B

Using $F = kx$, where x is stretched length minus original length L,

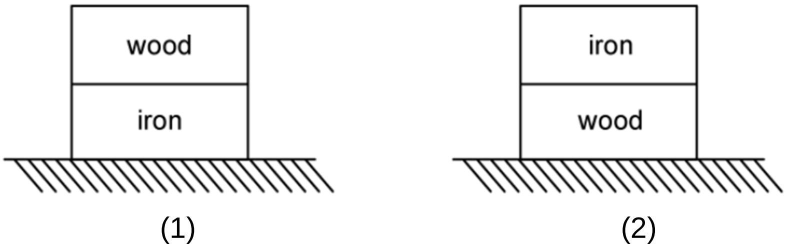
$30 = k(58 - L)$ ---- (1)

$51 = k(72 - L)$ ----(2)

Solving the two equations simultaneously,

L = 38 cm

10. Two blocks, one made of wood and the other of iron, are arranged at rest on the ground.



Which of the following statements is correct?

A The force exerted by the ground on the iron block in (1) is greater than the force exerted by the ground on the wooden block in (2) because the iron block, being denser than the wooden block, exerts more force on the ground.

B The force exerted by the wooden block on the iron block in (1) is equal to that exerted by the iron block on the wooden block in (2).

C The force exerted by the iron block on the wooden block in (1) is bigger than that exerted by the wooden block on the iron block in (2).

D The force exerted by the wooden block on the iron block in (1) is smaller than the force exerted by the ground on the wooden block in (2).

Ans: D

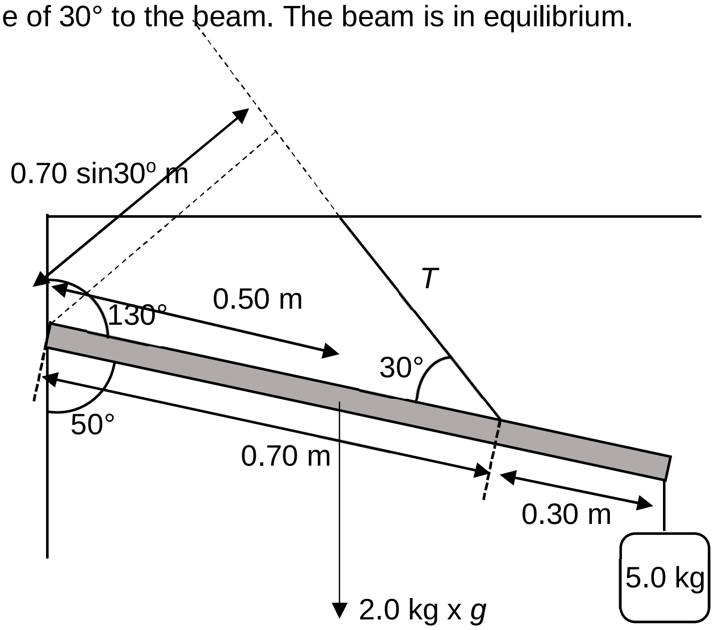
Option A: This is wrong because the normal reaction force that the ground exerts on the iron in (1) and wood in (2) is the same, since the normal reaction force = total weight of the two blocks, which are the same in both situations.

Option B: The force that the wooden block exerts on the iron block in (1) is equal to the weight of the wooden block and the force that the iron block exerts on the wooden block in (2) is equal to the weight of the iron block. Hence, the two forces are different in magnitudes.

Option C: The force that the iron block exerts on the wooden block in (1) is equal and opposite to the weight of the wooden block and the force that the wooden block exerts on the iron block in (2) is equal and opposite to the weight of the iron block. Hence, the two forces are different in magnitudes.

Option D: The force exerted by the wooden block on the iron block in (1) is equal to the weight of the wooden block. The force exerted by the ground on the wooden block in (2) is equal and opposite to the combined weight of the iron and wooden boxes. So D is correct.

11. A 1.0 m long uniform beam has a mass of 2.0 kg and has a further mass of 5.0 kg attached at the end. It is in contact with a wall on one side and is supported by a wire at an angle of 30° to the beam. The beam is in equilibrium.



What is the tension, *T*, in the wire?

A 69 N **B** 84 N **C** 110 N **D** 130 N

Ans: D

By the principle of conservation of moments,

Take pivot about contact point on the wall.

Sum of clockwise moments = sum of anticlockwise moments

$$(5.0)(9.81)(1.0)\sin 50° + 2(9.81)(0.50)\sin 50° \times 1.0 = T \sin 30° \times 0.70$$

T = 129 N

12. Which row in the table gives the gravitational potential energy, the elastic potential energy and the kinetic energy of a bungee jumper during the first fall? Air resistance is negligible.

		Gravitational potential energy/ kJ	Elastic potential energy/ kJ	Kinetic energy/kJ
A	top middle bottom	120 60 0	0 10 120	0 50 0
B	top middle bottom	120 60 0	0 30 60	0 30 60
C	top middle bottom	120 60 0	0 30 120	0 60 0
D	top middle bottom	120 60 0	0 60 120	0 0 0

Ans: A

At the top: There is only GPE. Hence, EPE and KE equal to 0.

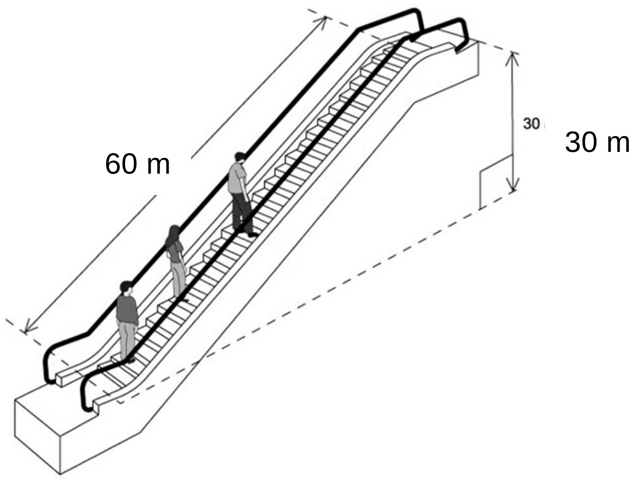
At the bottom: All GPE is lost and converted to EPE as it is momentarily at rest, hence KE = 0. Option B is wrong.

At the middle: GPE lost is converted to gain in EPE and KE. Option D is wrong

The total energy stays constant at 120 kJ. Option C is wrong.

Only Option A gives the correct combinations of energy at the different positions.

13. An escalator is 60 m long and lifts passengers through a vertical height of 30 m, as shown.



To drive the escalator against the forces of friction when there are no passengers requires a power of 2.0 kW.

The escalator is used by passengers of average mass 60 kg and the power to overcome friction remains constant.

How much power is required to drive the escalator when it is carrying 20 passengers and is travelling at 0.75 m s^{-1}?

A 4.4 kW

B 6.4 kW

C 8.8 kW

D 10.8 kW

Ans: B

Power required to drive the escalator with 20 passengers

= power to drive the escalator when there are no passengers + power to drive 20 passengers of an average mass of 60 kg each

$$= P_{escalator} + Fv$$

$$= P_{escalator} + (mg\sin\theta)v$$

$$= 2.0\times10^3 + 20(60)(9.81)\left(\frac{30}{60}\right)(0.75)$$

= 6414 = 6.4 kW

14. A turntable is rotating at a constant number of revolutions per second. What is the relationship between the angular velocity of a point on the turntable and the distance of the point from the centre of the turntable?

A Angular velocity is directly proportional to the distance.

B Angular velocity is inversely proportional to the distance.

C Angular velocity is directly proportional to the distance squared.

D Angular velocity is independent of distance.

Ans: D

Given number of revolutions per second, f = constant

$\therefore$ angular velocity $\omega = 2\pi f$ is a constant, independent of distance.

15. A bird is flying in a horizontal circular path at constant speed. Its wings are inclined at an angle to the horizontal as shown in the diagram.

Which of the following statements about the motion of the bird is correct?

A The kinetic energy of the bird is constant because no work is done.

B The bird is in equilibrium because the upward lifting force on bird balances its weight.

C The momentum of the bird is conserved because there is no net force acting on it.

D The acceleration of the bird is zero because the bird is flying at constant speed.

Ans: A

The bird is moving in a circular motion, so there is a centripetal force (aka net force) towards the centre of circle. Hence the bird is not in equilibrium and has a centripetal acceleration.

Since the centripetal force is perpendicular to the direction of motion, no work is done and the k.e. remains constant.

16. A satellite of mass *M* is in circular orbit with radius *r* around the Earth with a period of *T*. A second satellite of mass 2*M* moves around the Earth with radius 4*r*. What is the period of this second satellite in terms of *T*?

A $\frac{T}{4}$

B 2 *T*

C 4 *T*

D 8 *T*

Ans: D

For the 1st satellite,

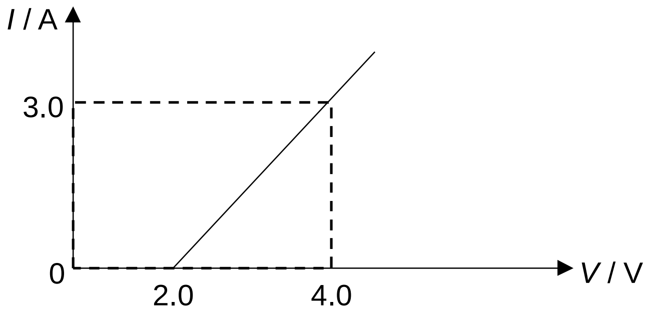
$$\frac{GM_E M}{r^2} = Mrw^2$$

$$\frac{GM_E M}{r^2} = Mr(\frac{2\pi}{T})^2$$

$$T = 2\pi\sqrt{\frac{r^3}{GM_E}}$$

For 2nd satellite, $T' = 2\pi\sqrt{\frac{(4r)^3}{GM_E}} = 8T$

17. The graph below shows how the current ***I*** flowing through an electrical device varies with the potential difference *V* applied across it:



What can be said about the resistance of the device as *V* increases?

A It is constant at 1.3 Ω
B It is constant at 0.67 Ω
C It increases
D It decreases

Ans: D

Note that resistance is not calculated from the inverse of the gradient of the *I* – *V* graph. It is simply calculated from the ratio $\frac{V}{I}$.

The graph shows that as *V* increases, $\frac{V}{I}$ decreases.

18. A cell is connected in series with a 4.0 Ω resistor and a switch. An ideal voltmeter is connected across the cell.

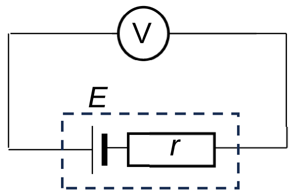
When the switch is opened, the voltmeter reads 6.0 V. When the switch is closed, the voltmeter reads 5.5 V.

What is the e.m.f. *E* and internal resistance *r* of the cell?

	E / V	*r* / Ω
A	5.5	0.33
B	5.5	0.36
C	6.0	0.33
D	6.0	0.36

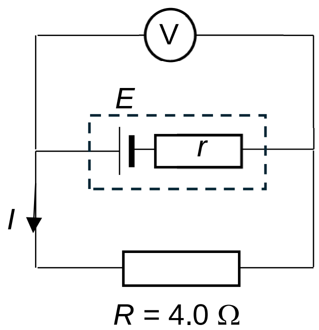
Ans: D

Switch opened:



No current flows from the cell as the voltmeter has infinite resistance. So the p.d. across the internal resistance r = 0. The voltmeter is just measuring the e.m.f, which is therefore 6.0 V.

Switch closed:



Note that the voltmeter is also reading the p.d. across *R*.

So $V = IR$

$$I = \frac{V}{R}$$

$$= \frac{5.5}{4.0}$$

$$= 1.375 \text{ A}$$

For the whole circuit, $E = I(R + r)$

$$r = \frac{E}{I} - R$$

$$= \frac{6.0}{1.375} - 4.0$$

$$= 0.36 \text{ A}$$

19. ‘A source has an e.m.f. of 3.0 V.’

What does the above statement mean?

A For every coulomb of charge delivered by the cell, 3.0 J of other forms of energy is changed to electrical energy.

B For every coulomb of charge delivered by the cell, 3.0 J of electrical energy is changed to other forms of energy.

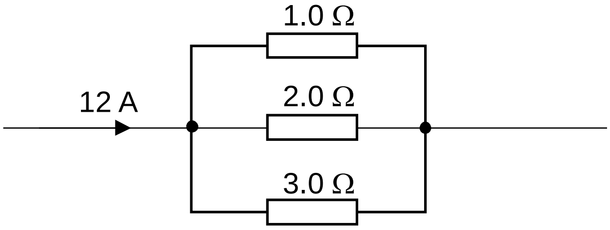
C For every coulomb of charge delivered by the cell, 3.0 J of other forms of energy is changed to electrical energy per second.

D For every coulomb of charge delivered by the cell, 3.0 J of electrical energy is changed to other forms of energy per second.

Ans: A

e.m.f. is defined as the amount of other forms of energy converted to electrical energy per unit charge delivered by the source of e.m.f.

20. A network of 3 resistors is shown below. The total current flowing through the network is 12 A:



What is the current flowing through the 3.0 Ω resistor?

A 2.0 A **B** 2.2 A **C** 4.0 A **D** 7.3 A

Ans: B

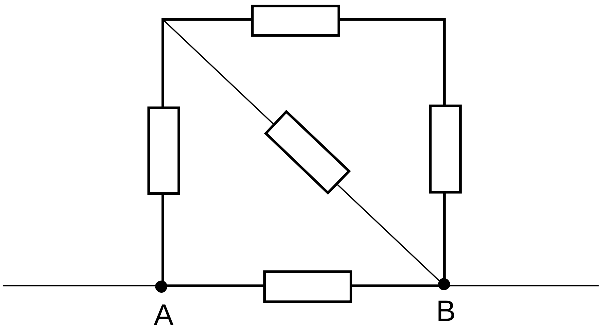
First, find the p.d. across the entire network. To do that, must find the total resistance first.

Total resistance $R = \left(\frac{1}{1.0} + \frac{1}{2.0} + \frac{1}{3.0}\right)^{-1}$
$= 0.5455\ \Omega$

p.d. across entire network = IR
$= 12 \times 0.5455$
$= 6.545$ V

$\therefore$ current through 3.0 Ω resistor = $\frac{6.545}{3.0}$
$= 2.2$ A

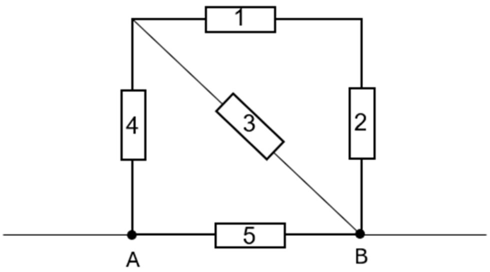
21. The diagram below shows a network of resistors, each of resistance 2.0 Ω:



What is the total resistance between the points A and B?

A 1.0 Ω **B** 1.3 Ω **C** 2.0 Ω **D** 2.6 Ω

Ans: B



Step 1: combined 1 and 2 in series = 4.0 Ω

Step 2: combine in parallel with 3: $\left(\frac{1}{2.0}+\frac{1}{4.0}\right)^{-1}$ = 1.333 Ω

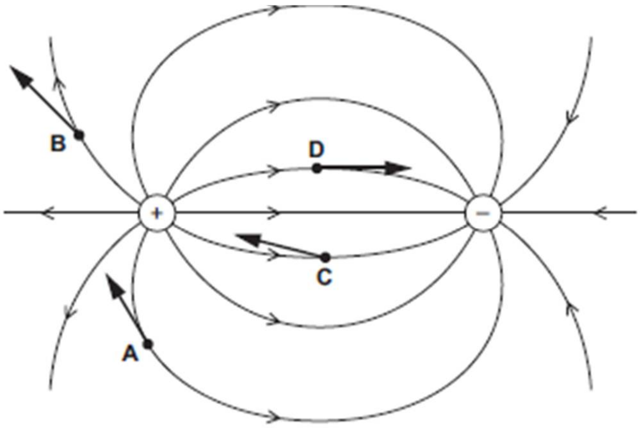
Step 3: combined in series with 4 = 3.333 Ω

Step 4: combine in parallel with 5: $\left(\frac{1}{2.0}+\frac{1}{3.333}\right)^{-1}$ = 1.25 Ω

22. The diagram below shows the electric field near a positively charged sphere and a negatively charged sphere.

Four electrons, **A**, **B**, **C** and **D** are shown at different positions in the field.

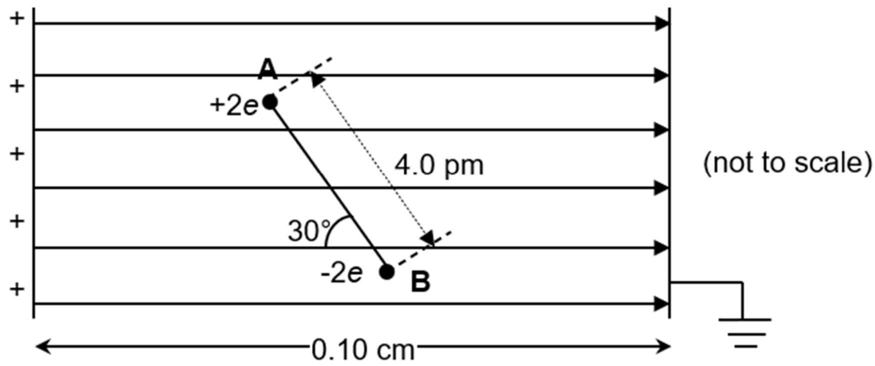
On which electron is the direction of the force on the electron shown correctly?



Ans: A

The tangent to the electric field lines gives the direction of the electric force acting on a positive test charge placed at that point. Since the object placed is negatively charged, the direction of the force it experiences is opposite the direction of the tangent vector. Thus A.

23. Two ions **A** and **B,** at a distance of 4.0 pm apart, are linked to form a molecule. They are situated between a pair of charged parallel plates placed a distance of d = 0.10 cm apart. The line joining **A** and **B** is at an angle of 30° to the direction of the electric field as shown in the diagram below.



Given that the electric field strength between two parallel plates is 2.0×10^{5} N C^{-1}, what is the torque on the molecule **AB**?

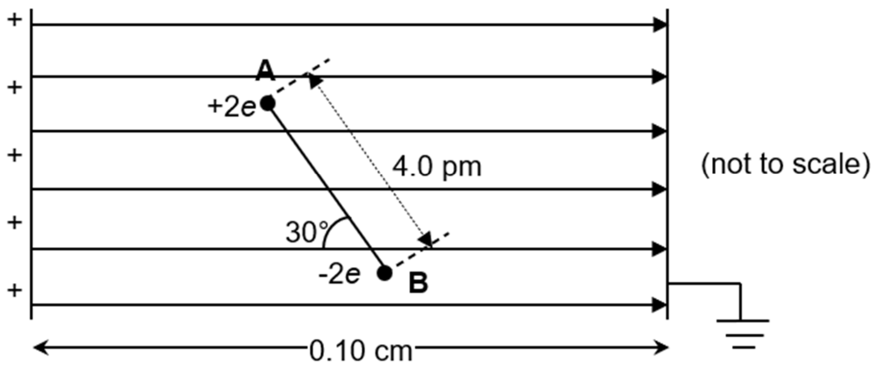
A 1.3×10^{-25} N m

B 2.2×10^{-25} N m

C 2.6×10^{-25} N m

D 5.1×10^{-25} N m

Ans: B

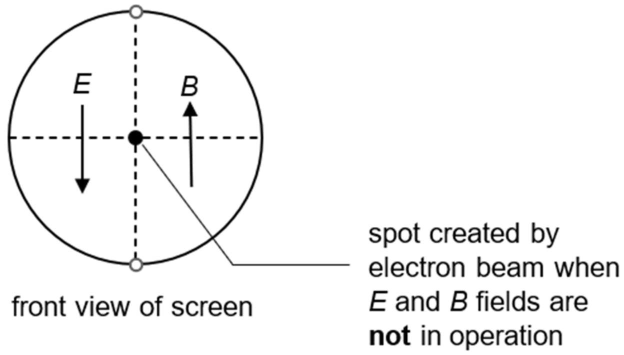


Consider the perpendicular component of the force acting on the A: the force is $F_{\perp} = qE\cos 30^{\circ}$

Thus the torque due to the couple is

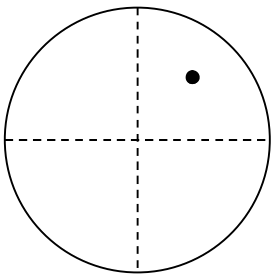
$$\begin{aligned}\tau &= F_{\perp}d = 2eE\cos 30^{\circ} \times d \\ &= 2 \times \left(1.6 \times 10^{-19}\right) \times \left(2 \times 10^{5}\right) \times \cos 30^{\circ} \times \left(4 \times 10^{-12}\right) \\ &= 2.22 \times 10^{-25} \text{ N m}\end{aligned}$$

24. In a cathode-ray oscilloscope tube, the electron beam passes through a region where there is an electric field directed vertically downwards and a magnetic field directed vertically upwards as shown in the diagram below.

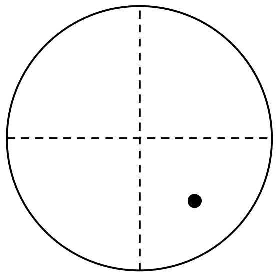


Which of the diagrams below shows a possible position of the spot on the screen when both fields are operating together?

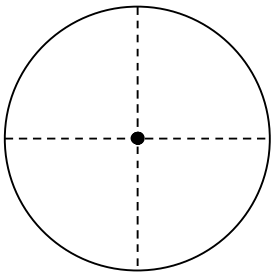
A



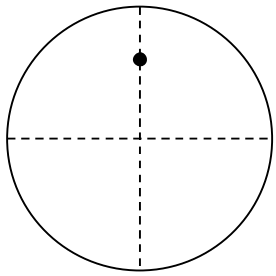
B



C



D



Ans: A

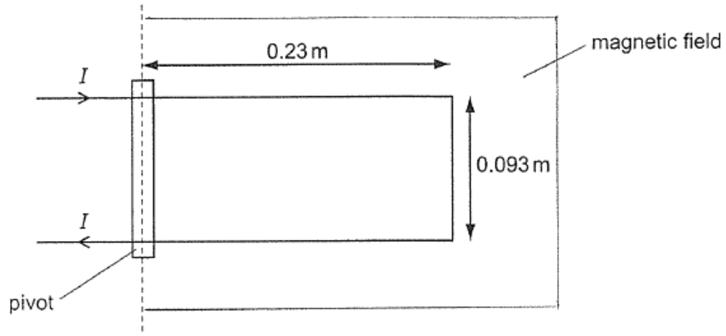
Since the electric field is downwards, the electrons will be deflected upwards by it.

Applying Fleming's left-hand rule: Since the magnetic force is upwards, the electrons will be deflected rightwards by it (from our perspective).

Thus combining these two effects gives us a deflection within the top right quadrant.

25. A current, *I* of magnitude 9.6 mA is passed into a current balance which consists of a U-shaped wire placed of negligible mass in a region of constant magnetic field which is in the plane of the paper and perpendicular to the pivot.

The U-shaped wire has length 0.23 m and the arms are 0.093 m apart, as shown in the diagram below.



The U-shaped wire experiences a turning moment about the pivot of value 4.7×10^{-6} N m.

What is the magnitude of the magnetic flux density of the constant magnetic field?

A 5.27 mT **B** 22.9 mT **C** 45.8 mT **D** 4.37 T

Ans: B

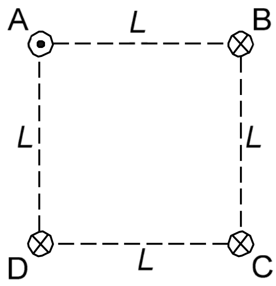
Magnetic force experienced by the wire, $F_B = BIL\sin\theta$

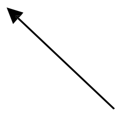
Moment produced, $F_B \times d = 4.7\times10^{-6} \Rightarrow \left(BIL\sin\theta\right)\times d = 4.7\times10^{-6}$

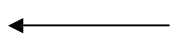
Therefore, magnetic flux density,

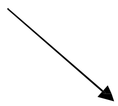
$$B = \frac{4.7\times10^{-6}}{\left(IL\sin\theta\right)d} = \frac{4.7\times10^{-6}}{\left(9.6\times10^{-3}\right)\left(0.093\right)\left(\sin 90^\circ\right)\left(0.23\right)} = 22.9\,\mathrm{mT}$$

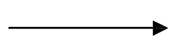
26. Four identical wires A, B, C and D carry currents, of equal magnitude, in the directions as shown in the figure below. What is the direction of the resultant magnetic force experienced by wire A?



A 

B 

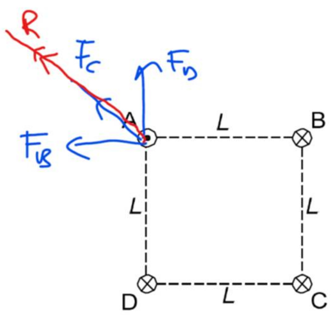
C 

D 

Ans: A

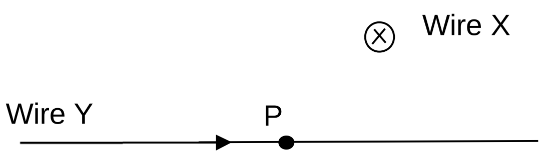
Parallel conductors carrying currents in the *opposite* direction will *repel* each other. So wire A is repelled by the other 3 wires.

Therefore, the resultant, *R* of the three forces acting on wire A is as shown below:



27. Two long straight current carrying wires, X and Y are placed perpendicular to each other.

Current flows into the page in Wire X and from left to right in Wire Y, as shown in the figure below.



What is the direction of the force acting on wire Y at point **P** due to the magnetic field produced by wire X?

A Into the page

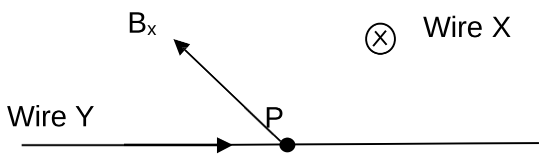
B Out of the page

C Towards Wire X

D Away from Wire X

Ans: B

By *Right Hand Grip Rule*, direction of the magnetic field produced by wire X is shown below:



Therefore, by *Fleming's Left Hand Rule*, direction of the magnetic force will be *out of the page*.

28. Which of the following statements is true?

A α particles can be stopped by 1 m of lead.
B β particles can be deflected when travelling parallel to a magnetic field.
C γ particles can be stopped by paper.
D α, β and γ particles are all charged particles.

Ans: A

Option A: if α particles can be stopped by a thin piece of paper, it can surely be stopped by 1 m of lead.

Option B: β particles, which are charged particles, travelling parallel to a magnetic field will not experience a magnetic force. They need to cut across the magnetic field to experience a magnetic force.

Option C: γ particles (or rays) can only be stopped by about 10 cm of lead. They can't be stopped by paper.

Option D: γ particles (or rays) are uncharged electromagnetic radiation.

29. In the Rutherford α-scattering experiment, most of the α-particles pass through the gold foil with little or no deflection. This is because

A most of the atom is empty space.
B the nucleus is positively charged.
C the nucleus contains most of the mass of the atom.
D the α-particles are moving at high speeds.

Ans: A

Option A: Because most of the gold atom is empty space, the α-particles can pass through mostly unhindered.

Option B: This option explains why some α-particles are deflected.

Option C: This option explains why some of the deflected α-particles are deflected through large angles.

Option D: This option is not a conclusion of the Rutherford α-scattering experiment.

30. A radioactive nuclide X with a half-life of 5.0 days decays into a stable nuclide Y.

Starting with an initially pure sample of X, what is the ratio $\dfrac{\text{number of nuclei of Y}}{\text{number of nuclei of X}}$ after 15 days?

A 1:8 **B** 1:7 **C** 7:1 **D** 8:1

Ans: C

15 days = 3 half lives. Fraction of X remaining = $\left(\dfrac{1}{2}\right)^3 = \dfrac{1}{8}$.

So $\dfrac{7}{8}$ of the sample has turned to Y.

$$\frac{\text{number of nuclei of Y}}{\text{number of nuclei of X}} = \frac{7/8}{1/8}$$
$$= 7:1$$

End of paper