Worked solutions Unit 3A

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Fairground physics

E1



E2 A. Inside column, as a smaller distance is covered in the same time period, which means that the centripetal force is less on the small child

E3 Outside column, as a greater distance is covered in the same time period, which means that the centripetal force will be greater on the older child.

E4



E5



E6



E7



E8



E9



E10



E11



E12 Same maximum speed, as the mass of the car and riders cancels out of the equation.

E13



E14

100.0% 90.0% 81.0% 72.9% 65.6% 59.0%

E15



E16



E17



E18 A 2.00g ride can be created if the accelerating force is vertical as opposed to horizontal, for example a 2.00g force can be experienced at the bottom of a curve.

E19



E20



E21 a



b



E22



E23



E24



Power distribution and generation

E1



E2 a



b i



ii The current in the secondary coil of a step-down transformer is always greater than the current in the primary coil, as current and voltage are inversely proportional in a transformation.

E3



Substituting into P = VI:



This is too large to run all these appliances at once; the extension cord on the power pack could heat up too much.

E4 a





b





c They should be able to use some appliances; however, lights would not be as bright, motors would not go as fast. Electronic devices may not function at all.

d





e







Chapter 1 Analysing motion

1.1 Projectile motion

1 a



b



c The only force acting on the ball is gravity, therefore the only acceleration is  
 g = –9.80 m s–2.

d



e



2 a Horizontal velocity remains constant, so vx = 10.0 m s–1.

b



c



d



e



f

***F***gravity

3 a



b 

c 

4 a



b



c



5 a



b



c The acceleration of the ball is constant, due to gravity = –9.80 m s–2.

6 a At its maximum height, this is the point at which the ball has zero vertical velocity, while maintaining its horizontal velocity.

b 

c 

d

***F***gravity

7 a



b



c



8 C

9 a



b



c



d



e



f



g



10 a



b



c



1.2 Circular motion in a horizontal plane

1 a A, D

b She has continued to travel in a straight line, while the car has turned, so the right side of the cabin is actually accelerating towards her.

2 a 

b 

c



3 a



b The force that causes the centripetal force is the reaction of the sideways frictional force of the car’s tyres on the road, that is the sideways force of friction of the road on the car’s tyres.

4 a 

b west

5 The car would probably skid off the road as the centripetal force required would increase to a value greater than the force of friction could provide.

6 a



b The forces are unbalanced as she is accelerating. According to Newton’s first law an unbalanced force will cause an object to change its motion, in this case the direction of the motion is changing, not the magnitude.

c



d The sideways reaction force of the skate on the ice, which is the sideways force of the ice on the skate.

7 a



b



c



d



e The force causing the centripetal acceleration of the ball is the tension force of the cable on the ball.

f The ball would continue in a straight line that is tangential to the circular path at the point at which the wire breaks.

8 a



b The forces acting on Ella are gravity and the tension force of the rope on her.

c Ella’s acceleration is towards the centre of rotation about the pole.

d



e



9 a



b



***F***g

***F***c

Φ

θ

Φ

10 The driver will have to turn the car’s tyres down the track to enable the horizontal component of the sideways frictional force to help turn the car. The combined centripetal force of the banked track and the horizontal component of the sideways frictional force will enable the car to turn at this higher speed while maintaining the same radius as before.

1.3 Circular motion in a vertical plane

1 a The acceleration is towards the centre of the circular path of the yo-yo.

b At the bottom of the circular path the tension in the string is greatest.

c At the top of the circular path the tension in the string is lowest.

d At the bottom of the circular path where the tension in the string is greatest.

2



3 a The force of gravity and the reaction force of the road on the car.

b



c Yes it is possible, however it is her apparent weight she was ‘feeling’ not her mass, which doesn’t change. The force that the seat applies to her is less as she goes over the hump, therefore she feels like she is lighter on the seat.

d



4 a



b



c



5



6



7



8



9 a



b



10 The wire is more likely to break when the ball is moving through position X as the tension in the wire is three times the tension it had when it was stationary at point X.

1.4 Vectors and free-body diagrams

1 a



b



c



2

a



b



c



3 a



b



c

44 a



b



c



5 a



b



c



6 a



b The plane should steer south 14.0° east to maintain a southerly path.

c



7 a



***F***ground on trolley

***F***gravity on trolley

***F***push on trolley

b

c



8 a



b



9

***F***club on ball

***F***gravity on ball

Ftee on ball

10

***F***air resistance on ball

***F***gravity on ball

1.5 Motion in a straight line

1 a A to B: Displacement 40 cm to the right, Distance 40 cm

b C to B: Displacement 10 cm to the left, Distance 10 cm

c C to D: Displacement 20 cm to the right, Distance 20 cm

d C to E and then to D: Displacement 20 cm to the right, Distance 80 cm

2 a Distance 80.0 km

b Displacement 20.0 km north

3 a 10 m down

b 60 m up

c 70 m

d 50 m up

4 displacement

5 a D

b D

c C

d A

6 a 39 steps

b 1 step west of the clothes line

c 1 step west

7 a



b



c



d



8 a



b



c



9 a



b



10 a



b



c 0 m

d 0 m s–1

1.6 Energy and momentum

1 a



b



c



2 a



b



c This collision is elastic as no kinetic energy is lost in the collision.

d This is an unrealistic situation as is all macroscopic collisions some kinetic energy is always lost in the form of heat or sound.

3 a



b



c Some energy potential energy would have been lost to heat or sound energy as the firefighter slid down the pole, therefore there would be less energy converted into kinetic energy.

d The work done is equal to the gain in energy of the firefighter, equal to 2.00 × 103 J.

e



4 D

5 a



b



c



d Impulse is equal to change in momentum = 1.44 kg m s–1 up.

6 a



b



c According to Newton’s third law, the force of the ball on the floor is 29.6 N down

7 a



b



c



8 a



b The initial momentum has gone into changing the momentum of the other vehicle.

c



d



9 Mary was correct, as the momentum before is equal to the momentum after, so the momentum of the railway tanker and water (combined) will be equal to the sum of the momentum of the tanker and water (separated). The sum of the masses of the water and tanker will be the same after as it was before therefore the speed of the tanker and water will be the same after as it was before.

10 a



b



c



Chapter 1 Review

1 a



b



2 a The force increases as the bounce continues to the point where the springs are stretched to their maximum, then decreases as the bounce continues to the point where Hannah leaves the trampoline. The force is usually named the reaction force.

b D

3 a



b



c



4 a





b



c



d



5



6



7 D

8



9 a



b



c



d



e



f



10 

11



12 

13 C

14



15



This answer tells us that the force of air resistance is insignificant when compared to the force due to gravity on the ball.

16 a .



b C



c D



d



17 a



b 

c



18 a



b



c



19 a 

b



c 

20



21



22 a



b



23



24 C



25 B

26 a A

b D

c C

27



28 a



b



c 

29 C

30 a i



ii



b D

Chapter 2 Applying forces

2.1 Gravitational fields

1 a



b



c



d



2 a



b



3



4



5 a



b



6



7



8 a



b



c



9 Saturn’s mass is approximately 100 times that of Earth, while the radius of Saturn is only 10 times that of earth. When the radius of the planet is squared the factor of 10 becomes 102, which is enough to cancel out the factor of 100 by which the mass of Saturn is greater.

10



2.2 Satellite motion

1 D

2 As the satellite does not change its energy while orbiting around the Earth, it doesn’t change its height above the surface of the Earth so its gravitational potential energy does not change, and its speed doesn’t change so its kinetic energy doesn’t change.

3



4 The source of this force is the gravitational attraction of the Earth on the satellite.

5 a



b



c



6 a



b



7



8 a



b



c



9 a i



ii



b



10



2.3 Torque

1 a .The axis of rotation is the tap spindle; the lever arm is approximately 0.04 m

b The axis of rotation is the axle of the wheel; the lever arm is approximately 1 m

c The axis of rotation is the end of the tweezers; the lever arms are approximately 0.07 m

d The axis of rotation is the place in which the screwdriver contacts the edge of the tin; the lever arm is approximately 0.2 m

2 a The line of application of the force is a larger perpendicular distance from the hinges (pivot point) when the force is applied to the handle than when it is applied to the centre of the door.

b Using a long crowbar with a small rock as a pivot a large force can be applied to the large rock if a small effort arm is used with a long effort arm, a ratio of load arm to effort arm of 1:10 will multiply the force you apply by ten times.

3



4



5 a



b Cranes use counter-weights on the other side of the pivot point to the load to provide an opposing torque to balance the torque due to the load.

6 a



b



c



***F***

*r*⊥

60.0°

*r*

7 The weights provide a large counter torque should the performer overbalance. Only a small movement of the pole is enough to balance the torque provided by the performer overbalancing.

8 The bench will not work successfully. The supports should be moved so that the centre of gravity is between the supports or bolts could be used to attach the left hand support to the bench-top.

9 a The weight of the bag will produce a torque about a pivot point around the base of the spine, which will tend to rotate the torso to the right. To compensate for this the person must lean to the left, or by holding the left arm out from the body to move it farther from the pivot point.

b



10 a



b As the perpendicular distance from the line of action of the load to the pivot point does not change, then the torque does not change.

c



2.4 Equilibrium

1 A, B, D

2



3



4



5°

***F***T vert

***F***T

5



6



7 a

***F***wt

***F***T

***r***2

***r***1

30°



b



c



8

X

Y

***F***wt beam

***F***wt train

*r*1

*r*2

*r*3



65°

*r*1

9 a



65°

*r*1

b



c



65°

*r*1

10 a



b



11 a



b



Chapter 2 Review

1



2 D

3 a D

b B

c C

d A

e A

4



5 a



b C

6



7 a



b



c



8 a C

b The satellite will always be positioned above the same location on Earth therefore radio and TV signals can be exchanged with the satellite from any location on Earth that has a line of sight view of the satellite

c



9 a

b



c



10 a The work done to increase the kinetic energy if the rock is equal to the area under the curve from   
3.00 × 106 m to 2.50 × 106 m



b



c



d From the graph, at 2.50 × 106 m, F = 70 N



11 a



b



c



12



13 B

14



15



16



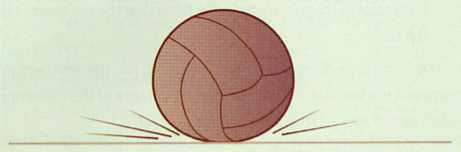
17



18



19



***F***ground on ball

***F***gravity on ball

20 a C

b The forces must be on different objects and be equal in magnitude.

21



22



The wrecker could hit the wall higher up to increase the radius.

23 E



*r*⊥

24



*r*⊥

25 B



26 B

27



28



29 a

r1 r2

***F***load

***F***c-w

pivot



b This reduces the torque acting on the crane making it less likely that the crane will topple over.

30 a



b This torque would cause the barrier to bend slightly to the left causing tension at Y and compression at X, as concrete can withstand more compression than tension it is more likely to crack at position Y.

Chapter 3 Understanding electromagnetism

3.1 Magnetic fields

1 B

2 C

3 a North

b North-east

c East

4 a South

b North

c Zero due to the two wires, but the Earth’s magnetic field still exists and will be directed north.

5 At point R, but only if the combined field from m and n are balanced by the Earth’s field.

6 a South

b South

c South, but only if it greater than the Earth’s field at that point.

7 a B, into the page

b 3B, into the page

c Zero

8 A

9 South

10 South

3.2 Force on current-carrying conductors

1 a



b



2



3 B

4 a



b



5 a



b



6 a



b



7 a



b



8 a



b



9 Magnetic flux due to wire N at point M is south.

10 a



b



c



3.3 Electric motors

1



2



3 0 N as the field and current are parallel.

4 Anticlockwise

5 D

6 a Down

b Up

7 Anticlockwise

8 a Down

b Up

c 0 N m

9 C

10 The commutator reverses the direction of the current through the coil of the motor at a particular point. This enables the resultant torque on the coil at that point keep the motor rotating in a constant direction.

3.4 Electric fields in circuits

1 a F doubles

b F quadruples

c F becomes attractive

d F quadruples

2



3 a



b As the charges on the Van de Graaff machine are mobile, and are of the same sign, they will repel each other so that they move to opposite sides of the dome, this will increase the distance between the ‘centre’ of the charges.

4 a



b



5 a



b



c



6



7 The potential difference of a car battery to your hand is 12 V, which causes an insufficient electric field to cause a current to flow through the air to your skin. The spark in a spark plug results from a potential difference of thousands of volts, which will cause current to flow through air to your hand.

8



9



10



3.5 Electric circuits

1 Either there is some internal resistance in the battery or there is some form of resistance in the circuit, which may be due to corroded connections.

2



3 a 0.25 A

b 2.40 V

4 a Yes

b If one bulb breaks the other will go out too.

5 a



b



6 a Lamp A gets brighter

b Lamp C turns off

c Current increases

d Potential difference across lamp B increases

e Potential difference across lamp C decreases

f Total power increases

7 a R1, R4 and R5

b R2 and R3

c R1, R4 and R5

8

|  |  |  |
| --- | --- | --- |
| R1 (Ω) | R2 (Ω) | Vout (V) |
| 1000 | 1000 | 10 |
| 3000 | 1000 | 5.0 |
| 400 | 100 | 4.0 |
| 900 | 100 | 2.0 |
| 2.0 | 3.0 | 12 |

9 a D

b F

c D

d A

10 a



b



c



d



Chapter 3 Review

1 B, C

2 B

3 A

4 a R4

b R2 and R3

c R4

d E2

5 a All four in series.

b Two in series that are connected to two in parallel.

c All four in parallel.

d One resistor that is connected to three in parallel.

6 a



b



7



8 a



b



9



10 a



b



11

|  |  |  |  |
| --- | --- | --- | --- |
| R1 (Ω) | R2 (Ω) | Switch | Vout (V) |
| 1000 | 2000 | Open | 60 |
| 2000 | 4000 | Open | 60 |
| 4000 | 2000 | Open | 50 |
| 8000 | 5000 | Closed | 0 |

12 a



b



13 a Y

b



c 

d



e



14 a Into the page

b Out of the page

c Out of the page

d Out of the page

15 5.00 × 10–5 T south

16 Into the page

17



18



19 North-west

20 C

21 a



b



c



22 a Out of the page

b Into the page

23 Zero

24 a Attraction

b Attraction

c Repulsion

25 Zero

26



27



28 Anticlockwise

29 D

Chapter 4 Generating electricity

4.1 Magnetic flux and induced currents

1



2



3 a



b



c



d



4 a Zero

b Negative

c Positive

d Negative

5 There must be a changing magnetic flux in the conductor that makes the coil, and the coil must be part of a complete circuit.

6 As S is closed a current in Y grows, which deflects the galvanometer needle to the right, and then drops to zero.

While S is closed, no current flows.

As S is opened a larger current in Y grows, which deflects the galvanometer needle to the left, and then drops to zero.

7 As the current in X steadily decreases the current in Y is constant and deflects the galvanometer needle to the left.

As the current in X steadily increases the current in Y is constant and deflects the galvanometer needle to the right.

8 a



b Zero

9 a



b



c 4.00 mA flowing from Y to X through the milliammeter.

10 a



b



c



4.2 Induced EMF: Faraday’s law

1 a



b Zero

c



d



2 a



b



c



3 a



b



4 a



b



5 D

6



7 C

8 a Out of the page

b Into the page

c Out of the page

9 a Positive

b Positive

c Negative

4.3 Electric power generation

1



2



3 The rate of change of flux increases as the angle increases.

4



5 a At 90° as the rate of change of flux is maximum at this point, the wire is moving perpendicular to the lines of flux at this point.

b



6 B

7 a C

b D

c C

d B

e D

8



9 a



b



c



d



10 a



b



c



4.4 Transformers

1 a 

b 

c 

2 a A, B, D

b A, B, D

3 a A

b B, D

4 Power losses occur when electrical energy is converted into heat energy in the copper windings and in the iron core. Energy losses in the core are due to eddy currents.

5 a B

b D

c A

6 a



b



c



7 a



b



c



8 The security light would not operate. In order for an EMF to be generated in the secondary coil a changing magnetic flux is required, a constant DC supply will create a constant field, therefore no EMF is induced in the secondary coil.

9 There is no power consumed in the primary coil during this time. This is because the change in flux in the transformer core is not causing any current in the secondary coil, so no energy is lost from the magnetic field. The change in flux in the primary coil will induce a back EMF, which is equal in magnitude and opposite in direction to the applied EMF if it is a perfect transformer. In reality there is some energy loss in the eddy currents in the core so some energy is used from the field and less energy is available to create the back EMF in the primary coil. This slight imbalance in the applied EMF and the back EMF results in a small current flowing in the primary coil and therefore some small power consumption occurs. This is why transformers should be unplugged when they are not being used.



4.5 Distributing electricity

1 a By transforming to higher voltages the current decreases, this allows thinner cables to be used. Also the power lost by the cables is reduced significantly as 

b The corona effect limits the voltage for power transmission. Differences in potential of 1000 V per centimetre will cause current to flow through air, At 500 kV this means that any ground source must be at least 500 cm away from the active wire. This becomes problematic for the design of the transmission towers and insulators used.

2 a



b



3 a



b



4



5 a



b



c



d



6 a



b



c



7 a



b



c



d



e



8 a



b



c



9 a



b



c



10 a



b



c



d No, as this results in a significant loss of power over the length of the transmission line (30%).

Chapter 4 Review

1 a



b



c



2 a



b



3 a current halved to 1.00 mA, period doubled to 20 ms = A

b current same as 2.01 mA, period halved to 5 ms = C

c current halved to 1.00 mA, period same as 10 ms = B

4 a To the left, as the soft iron core is induced to become a temporary magnet by the permanent magnet’s field.

b To the left, attraction.

c To the right, repulsion.

5



6 A**,** C

7 The direction would be from X to Y as according to Lenz’s law the EMF will be induced in a direction that causes a current that creates a magnetic field that opposes the change that is causing the current. Current from X to Y will cause a north pole at the top and a south at the bottom of the coil, which will oppose the north at the top of and the south at the bottom of the permanent magnet.

8 a



b



9 There is no induced current as there isn’t a complete circuit, as the switch is open.

10



11 To the right

12



13 To the left

14 a



b Zero current is induced in the loop, as both vertical sides of the loop have an EMF induced in the same direction (downwards). This means that each side produces equal and opposing EMFs so no current flows in the loop.

15



16 a



b



c



d



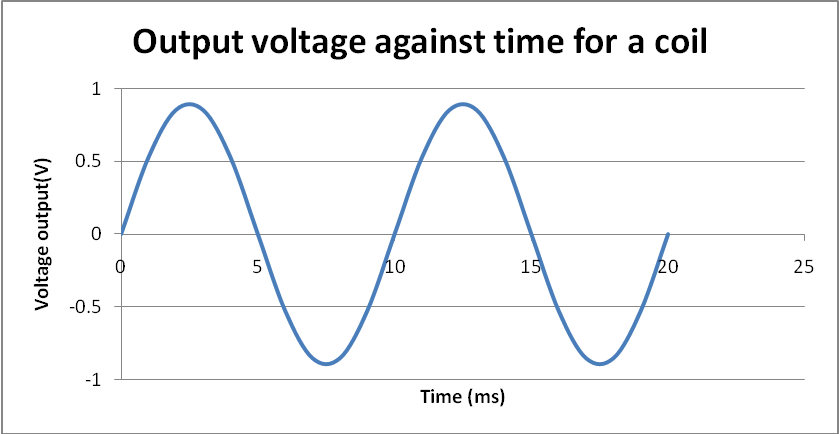
e No the current will stop. For an EMF to be induced, the flux must be changing in the loop, if it is not changing then no EMF is induced and therefore no current will flow.

17 a This is a quarter of the time so the EMF and therefore the current will increase by a factor of four = 2.00 × 10–4 A.

b



18 a



b



c Period halved to 5 ms, Vpeak doubles to 1.8 V, VRMS becomes 1.3 V.

19 a



b



c



20 a C

b A

c B

21 C

22 C

23 a



b



c



24 a



b



c



25 C

26



Set C is equivalent to 60 W.

27 a



b



c



d



28 a



The machine should work satisfactorily.

b By dropping the voltage by a factor of 10 the current is increased by a factor of 10. This would result in a significant power loss over the cable.

c



d



29 Appliances with built-in transformers or motors that require AC will not function correctly and could burn out. At full load there would be a power loss of about 555 W, or about 66 V difference in potential which would only leave about 173 V potential at the farmhouse.

30 He needs a step-down transformer with a turns ratio of 5 : 1.







This set-up would suit his purposes well.