Year 12 Physics

Practice Exam 1 (Units 3 & 4) Answers

Unit 3

Area of Study 1 How do things move without contact?

Question 1

a **A** (1 mark)

b **B** (1 mark)

c **G** (1 mark)

Question 2

a $E = \frac{V}{d} = \frac{200}{0.050}$ (1 mark)

$E = 4.0 \times 10^{3}$ V m^{-1} (1 mark)

b $F = qE = 1.6 \times 10^{-19} \times 4.0 \times 10^{3}$ (1 mark)

$F = 6.40 \times 10^{-16}$ N (1 mark)

c $W = qV = 1.6 \times 10^{-19} \times 200$ (1 mark)

$W = 3.2 \times 10^{-17}$ J (1 mark)

d $W = E_k = \frac{1}{2}mv^2$ (1 mark)

$3.2 \times 10^{-17} = \frac{1}{2} \times 1.7 \times 10^{-27} \times v^2$

$v = 1.9 \times 10^{5}$ m s^{-1} (1 mark)

Question 3

a $v = u + at$

$0 = 0.5 + a \times 10^{4}$ (1 mark)

$g = a = -4.8 \times 10^{-3}$ m s^{-2} therefore 4.8×10^{-3} m s^{-2} down (2 marks)

b $g = \frac{GM}{r^2}$

$4.8 \times 10^{-3} = \frac{6.67 \times 10^{-11} \times M}{(14 \times 10^{3} + 1.2)^2}$ (1 mark)

$M = 1.4 \times 10^{16}$ kg (1 mark)

Question 4

$\frac{T^2}{r^3} = \frac{4\pi^2}{GM}$

$r^3 = \frac{GMT^2}{4\pi^2}$ (1 mark)

$r^3 = \frac{6.67 \times 10^{-11} \times 1.99 \times 10^{30} \times (410 \times 24 \times 3600)^2}{4\pi^2}$

$r^3 = 4.22 \times 10^{33}$

$r = 1.62 \times 10^{11}$ m (2 marks)

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Question 5

a $V = IR$

$6 = I \times 4$ (1 mark)

$I = 1.5$ A

$v = 7.55 \times 10^3$ m s^{-1} (1 mark)

b $F = nIlB$

$F = 50 \times 1.5 \times 0.06 \times 0.08$ (1 mark)

$F = 0.36$ N (1 mark)

c Recognition that a conductor parallel to a magnetic field does not experience a force. (1 mark)

$F = 0$ N (1 mark)

d When the loop is at 90° to the magnetic field, the split in the commutator stops current flowing through the loop. Its momentum carries it past the vertical. (1 mark)

This reverses the direction of the current in the loop every half turn. (1 mark)

This reverses the direction of the forces acting on the sides WX and YZ, ensuring the continuous rotation of the loop. (1 mark)

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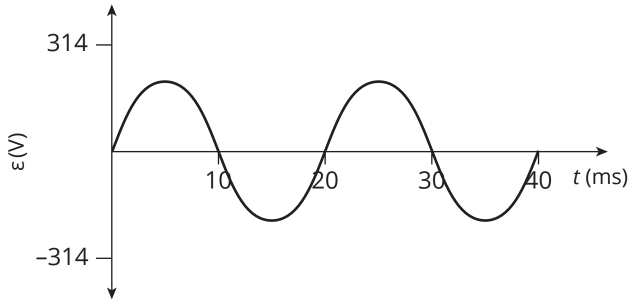
Question 6

a



time scale correct (1 mark)

vertical scale correct (1 mark)

two cycles of a sine graph shown (1 mark)

b $\Delta t = \frac{0.02}{4} = 0.005$ s

$\varepsilon = N\frac{\Delta\phi_B}{\Delta t}$

$\varepsilon = \frac{200 \times 0.5 \times 100 \times 10^{-4}}{0.005}$ (1 mark)

$\varepsilon = 200$ V (1 mark)

Question 7

a $\varepsilon = N\frac{\Delta\phi_B}{\Delta t}$

$\varepsilon = \frac{300 \times 0.01 \times 25 \times 10^{-4}}{200 \times 10^{-3}}$ (1 mark)

$\varepsilon = 0.0375$ V (1 mark)

b $V = IR$

$0.0375 = I \times 2.5$ (1 mark)

$I = 15$ mA (1 mark)

c The current would be from X to Y. (1 mark)

The induced current must oppose the increasing downward flux. (1 mark)

Question 8

a A coil of wire rotates in a magnetic field. (1 mark)

A current is created in the conductor as it rotates. (1 mark)

Diagram shows:

- magnet surrounding a coil
- coil rotating in magnetic field (1 mark)

b $\frac{N_2}{N_1} = \frac{V_2}{V_1}$

$N_2 = \frac{V_2}{V_1} \times N_1$

$N_2 = \frac{250}{1000} \times 2000$ (1 mark)

N_2 = 500 turns (1 mark)

c $P = VI$

200 000 = 1000 × I (1 mark)

I = 200 A (1 mark)

d $P = I^2R$

$P = 200^2 \times 0.2$ (1 mark)

P = 8000 W (1 mark)

e Power from the alternator can be stepped up further before it is transmitted. (1 mark)

This will send the power at high voltage but low current—this follows from $P = VI$. (1 mark)

Thus, power lost in the transmission lines will be reduced due to $P = I^2R$. (1 mark)

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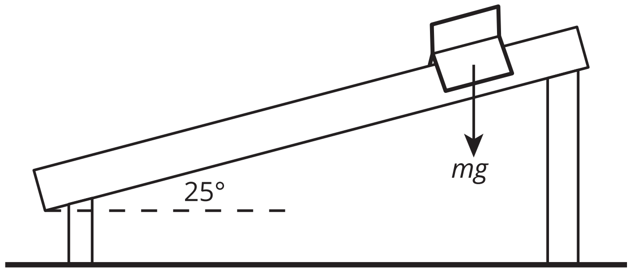
Question 9

a Two arrows, weight acting vertically down and normal force acting at right angles to the surface (1 mark)



b $s = ut + \frac{1}{2}at^2$ (1 mark)

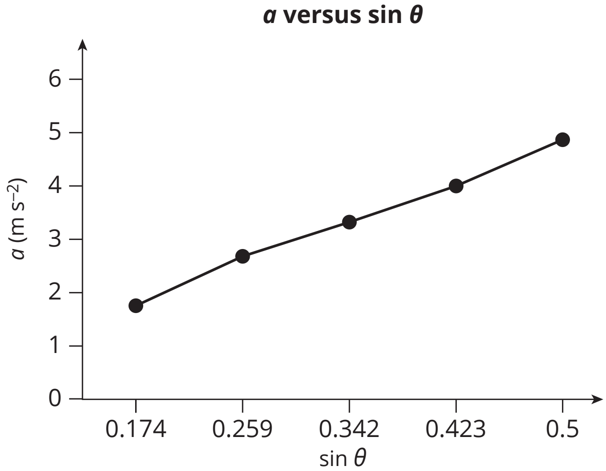
$s = 0 + \frac{1}{2}at^2$

$a = \frac{2s}{t^2}$ (2 marks)

c

θ (°)	*x* (m)	*t* (s)	*a* (m s⁻²)	sin θ°
10	2	1.5	1.78	0.174
15	2	1.2	2.78	0.259
20	2	1.1	3.31	0.342
25	2	1.0	4.00	0.423
30	2	0.9	4.90	0.500

d



correct axes labels (1 mark)

scale (1 mark)

plotting points (1 mark)

e The gradient is *g*. (2 marks)

f As θ increases, the acceleration increases. (1 mark)

a is proportional to sin θ. (1 mark)

The constant of proportionality in the graph is *g*. (1 mark)

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Question 10

a $v^2 = u^2 + 2as$

$0 = u^2 + 2 \times -9.8 \times 8$ (1 mark)

$u = 12.5$ m s^{-1} vertically (1 mark)

$12.5 = u_{launch} \sin 30°$

$u_{launch} = 25.0$ m s^{-1} at 30° (1 mark)

b $v = u + at$

$0 = 12.5 + -9.8t$

$t = 1.28$ s and total time is 2.56 s (1 mark)

$u = 25.0 \cos 30° = 21.7$ m s^{-1} (1 mark)

$s = ut$

$s = 21.7 \times 2.56$

$s = 55.6$ m (1 mark)

c Answers will vary. Here is one possibility: Start the ride from a raised ramp. (1 mark)

As the rider goes down the ramp, acceleration due to gravity will help the rider gain velocity and reach the take-off ramp at a higher speed. (1 mark)

This is due to the conversion of potential energy that the rider has at the top of a ramp to kinetic energy they go down the ramp. (1 mark)

Question 11

a The base of the test tube exerts a centripetal force which is transferred through the fluid to particles suspended in the liquid. (1 mark)

The direction of this force is towards the centre of the centrifuge which causes it to travel in a circular path. (1 mark)

b The direction of this force is towards the centre of the centrifuge which causes it to travel in a circular path. (1 mark)

$a = \frac{4\pi^2 r}{T^2}$

$a = \frac{4\pi^2 \times 0.05}{(8 \times 10^{-4})^2}$ (2 marks)

$a = 3.08 \times 10^6$ m s^{-2} (1 mark)

c $a = \frac{4\pi^2 r}{T^2}$

$a = \frac{4\pi^2 \times 0.15}{(8 \times 10^{-4})^2}$ (1 mark)

$a = 9.3 \times 10^6$ m s^{-2}

or recognition that the radius to the closed end is three times the radius of the open end: $a = 9.24 \times 10^6$ m s^{-2} (1 mark)

d $F = ma$ (1 mark)

$F = 0.0115 \times 9.24 \times 10^6 = 1.06 \times 10^5$ N (1 mark)

Question 12

a $F = k\Delta x$

$mg = k\Delta x$ (1 mark)

$2 \times 9.8 = k \times 0.2$

$k = 98$ N m^{-1} (1 mark)

b $E_s = \frac{1}{2}k\Delta x^2$

$E_s = \frac{1}{2} \times 98 \times 0.2^2$ (1 mark)

$E_s = 1.96$ J (1 mark)

c $E_s = \frac{1}{2}k\Delta x^2$

$E_s = \frac{1}{2} \times 98 \times 0.3^2$

$E_s = 4.41$ J (1 mark)

d total energy measured at $x = 0.3$ m $= 4.41$ J (1 mark)

At B: $4.41 = mg\Delta h + \frac{1}{2}mv^2 + \frac{1}{2}k\Delta x^2$

$4.41 = 2 \times 9.8 \times 0.1 + \frac{1}{2} \times 2 \times v^2 + \frac{1}{2} \times 98 \times 0.2^2$ (1 mark)

$\frac{1}{2} \times 2 \times v^2 = 4.41 - 1.96 - 1.96$ (1 mark)

$v = 0.7$ m s^{-1} (1 mark)

Question 13

$$L = \frac{L_0}{\gamma} = L_0 \times \sqrt{1-\frac{v^2}{c^2}}$$

$$60 = 75 \times \sqrt{1-\frac{v^2}{c^2}}$$

$$\frac{60}{75} = \sqrt{1-\frac{v^2}{c^2}}$$

$\left(\frac{60}{75}\right)^2 = 1 - \frac{v^2}{c^2}$ (1 mark)

$v^2 = 0.36c^2$

$v = 0.6c$ (1 mark)

Unit 4

Area of Study 1 How can waves explain the behaviour of light?

Question 14

a coherent light, e.g., laser light (1 mark)

Incoherent light will not result in the interference pattern observed by Young. There will not be the pattern of constructive and destructive interference that produces the bright and dark bands. (1 mark)

b (2 marks)

Change made	**Effect on spread of interference pattern**
increase slit separation	decreased spread
decrease slit separation	increased spread
increase slit to screen distance	increased spread
decrease slit to screen distance	decreased spread

$\Delta x \propto \frac{L}{d}$ (1 mark)

Δx increases when L increases

Δx decreases when d increases (1 mark)

c $PD = n\lambda$

$920 \times 10^{-9} = 2 \times \lambda$ (1 mark)

$\lambda = 4.6 \times 10^{-7}$ m

$\lambda = 460$ nm (2 marks)

d The dark and light bands correspond to regions of destructive and constructive interference. (1 mark)

Therefore, light behaves like a wave. (2 marks)

Question 15

a $n_1 \sin \theta_1 = n_2 \sin \theta_2$

$n_1 = \frac{n_2 \sin\theta_2}{\sin\theta_1}$

$n_1 = \frac{1.0 \sin 29°}{\sin 19°}$ (1 mark)

$n_1 = 1.49$ (1 mark)

b $n_1 v_1 = n_2 v_2$

$1.49 \times v_1 = 1.0 \times 3.0 \times 10^8$ (1 mark)

$v_1 = 2.0 \times 10^8$ m s^{-1} (1 mark)

c $n_1 \sin \theta_c = n_2 \sin 90°$

$1.49 \times \sin \theta_c = 1.0 \times 1$

$\sin \theta_c = \frac{1.0}{1.49}$ (1 mark)

$\theta_c = 42°$ (1 mark)

d Total internal reflection will occur. (1 mark)

e Medium 1 is more optically dense than medium 2. (1 mark)

Medium 1 has a higher absolute refractive index. (1 mark)

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Question 16

a from 1.5 m to 5.5 m = 4 m (1 mark)

b The particle is currently at the lowest point and will move up in the next instance. (1 mark)

c The energy is moving towards the right. (1 mark)

d $v = f\lambda$

$100 = f \times 4$

$f = 25$ Hz (1 mark)

$T = \frac{1}{f}$

$T = \frac{1}{25}$

$T = 0.04$ s (1 mark)

Area of Study 2 How are light and matter similar?

Question 17

energy per photon:

$E = hf$

$E = 6.63 \times 10^{-34} \times 2500 \times 10^6$

$E = 1.66 \times 10^{-24}$ J (1 mark)

total energy:

$P = \frac{E}{t}$

$E = P \times t$

$E = 1000 \times 1$ (1 mark)

$E = 1000$ J each second (1 mark)

number of photons per second $= \frac{1000}{1.66 \times 10^{-24}} = 6.02 \times 10^{26}$ (1 mark)

Question 18

a The single hydrogen electron is in the ground state, so it has energy of 13.6 eV. (1 mark)

The photon energy is greater than 13.6 eV, so the electron will acquire sufficient energy to be ejected from the atom. (1 mark)

b energy of ejected electron = 14.0 − 13.6 = 0.4 eV (1 mark)

in joules, $E = 0.4 \times 1.6 \times 10^{-19} = 6.40 \times 10^{-20}$ J (1 mark)

Question 19

a $\lambda = \frac{h}{mv}$

$\lambda = \frac{6.63 \times 10^{-34}}{9.1 \times 10^{-31} \times 1.8 \times 10^7}$ (1 mark)

$\lambda = 4.05 \times 10^{-11}$ m (1 mark)

b The radius of the diffraction pattern would decrease. (1 mark)

As $\lambda = \frac{h}{mv}$, an increase in velocity will reduce the wavelength. (1 mark)

As the amount of diffraction is proportional to the wavelength, decreasing λ will result in the radius of the diffraction pattern getting smaller. (1 mark)

c $E = \frac{hc}{\lambda}$

$E = \frac{6.63 \times 10^{-34} \times 3 \times 10^8}{4.05 \times 10^{-11}}$ (1 mark)

$E = 4.91 \times 10^{-15}$ J (1 mark)

d Diffraction is a property of wave-like behaviour. (1 mark)

Thus, as the electrons have exhibited a diffraction pattern, they must have wave-like properties. (1 mark)

Question 20

a drawing of line of best fit (1 mark)

h = gradient of line of best fit $= \frac{3.5 - 0}{(1.6 - 0.8) \times 10^{15}}$ (1 mark)

$h = 4.38 \times 10^{-15}$ eV s or 7×10^{-34} J s (1 mark)

b 3.5 eV, from extending the line of best fit back to the (vertical) energy axis (1 mark)

c According to the wave model, a threshold frequency for the incident photons would not be required. This is because the wave model predicts that all the incident photons would be absorbed, resulting in the electrons eventually gaining enough energy to escape the metal. This behaviour is not observed (1 mark)

The particle model correctly predicts that unless an incident photon has sufficient energy to enable an electron to escape the metal, the photon will not be absorbed. The threshold frequency is the minimum frequency for which photons will have enough energy to liberate an electron. (1 mark)

d $E = \frac{hc}{\lambda}$

$E = \frac{4.38 \times 10^{-15} \times 3 \times 10^{8}}{460 \times 10^{-9}}$ (1 mark)

$E = 2.86$ eV (1 mark)

$E_k = 2.86 - 2.1 = 0.76$ eV (1 mark)

$E_k = 0.76$ eV $= 1.22 \times 10^{-19}$ J (1 mark)

$E_k = \frac{1}{2} mv^2$

$v = \sqrt{\frac{2E_k}{m}} = \sqrt{\frac{2 \times 1.22 \times 10^{-19}}{9.1 \times 10^{-31}}}$ (1 mark)

$v = 5.18 \times 105$ m s^{-1} (1 mark)

e Cs line drawn parallel to Sc line (1 mark)

Cs line drawn to give energy axis intercept of 2.1 eV (1 mark)

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