A LEVEL PHYSICS

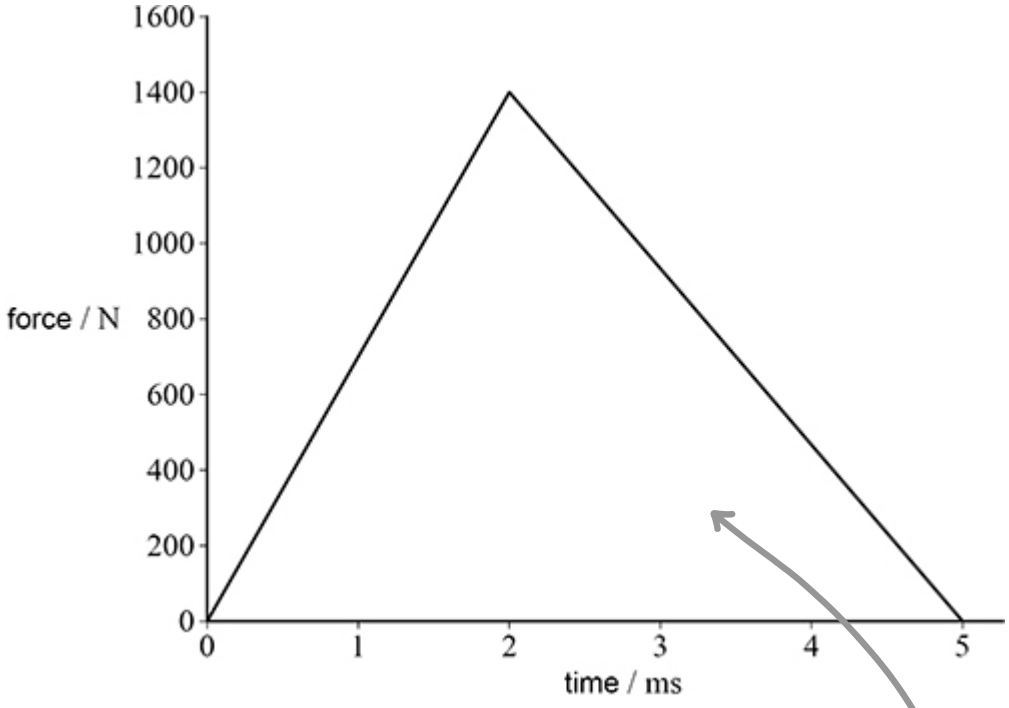
WORKED SOLUTIONS

1.1. SI Units and their Prefixes MCQ

Worked Solutions by Lewis Matheson from
ALevelPhysicsOnline.com in collaboration
with **PhysicsAndMathsTutor**.com

1. A stationary ball is free to move. The ball is hit with a bat.

The graph shows how the force of the bat on the ball changes with time.



The ball has a mass of 0.044 kg.

What is the speed of the ball immediately after being hit?

A 13 m s^{-1} ○

B 60 m s^{-1} ○

C 80 m s^{-1} ●

D 160 m s^{-1} ○

$F = \frac{\Delta p}{\Delta t}$

$\Delta p = F\Delta t$ = area under graph

$(\Delta p = mv - mu)$

$mv = \frac{1}{2} \times 5.0 \times 10^{-3} \times 1400$

$v = \frac{3.5}{0.044} = 79.5 \text{ ms}^{-1}$

(Total 1 mark)

2. Which is approximately equal to 3 kW h?

A 3×10^3 J ○

B 1×10^4 J ○

C 2×10^5 J ○

D 1×10^7 J ●

$3 \times 1000 \times 60 \times 60$

kW hour

$= 1.08 \times 10^7$ J

(Total 1 mark)

3. Which is the shortest distance?

A 10^{-19} Gm ○ $10^{-19} \times 10^{9} = 10^{-10}$

B 10^{-14} km ● $10^{-14} \times 10^{3} = 10^{-11}$

C 10^{-4} μm ○ $10^{-4} \times 10^{-6} = 10^{-10}$

D 10^{7} fm ○ $10^{7} \times 10^{-15} = 10^{-8}$

(Total 1 mark)

4. Which row shows SI unit prefixes in order of smallest value to largest value?

	Smallest			Largest
A	p	n	c	μ
B	p	n	μ	c
C	n	p	c	μ
D	n	p	μ	c

○ ● ○ ○

$p = 10^{-12}$, $n = 10^{-9}$, $\mu = 10^{-7}$, $c = 10^{-2}$

(Total 1 mark)

5. Mechanical power

A is a vector quantity. scalar ○

B is measured in J. W ○

C has base units of kg m^2 s^{-3}. ●

D can be calculated from force × distance moved. work ○

(Total 1 mark)

$P = Fv \therefore N\,ms^{-1} = kg\,ms^{-2} \cdot ms^{-1} = kg\,m^2s^{-3}$

6. Water waves of wavelength λ and wave speed v are related by $v = \sqrt{k\lambda}$ where k is a constant.

What is a possible SI unit for k?

$ms^{-1} = \sqrt{km}$

$m^2 s^{-2} = km$

$k = ms^{-2}$

A	$m\ s^{-2}$	●
B	$m\ s^{-1}$	○
C	$m^{\frac{3}{2}}\ s^{-1}$	○
D	$m^{\frac{1}{2}}\ s^{-1}$	○

(Total 1 mark)

7. Which quantities can be written in the fundamental units kg m^{-1} s^{-2}?

A	Tensile stress and kinetic energy $Pa + J$	○
B	The moment of a force and kinetic energy $Nm + J$	○
C	Young modulus and the moment of a force $Pa + Nm$	○
D	Young modulus and tensile stress $Pa + Pa$	●

F/A

$kg\ ms^{-2} \div m^2$

$kg\ m^{-1} s^{-2}$

(Total 1 mark)

8. Which is a correct statement about mechanical power?

(Same as Q5)

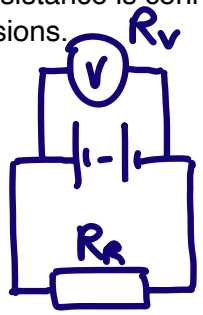
A	It is a vector quantity.	○
B	It is measured in J.	○
C	In fundamental units, its unit is kg m^2 s^{-3}	●
D	It can be calculated from force × distance moved.	○

(Total 1 mark)

9. A voltmeter has a resistance of 4.0 kΩ and reads 1.0 V for every scale division on the meter.

A power supply of emf 20 V and negligible internal resistance is connected across this voltmeter and a resistor in series. The voltmeter reads two divisions.

What is the value of the resistor?



2 div = 2.0V
∴ 18 V dropped across R_R

A 44 kΩ ○

B 36 kΩ ●

C 4.4 kΩ ○

D 3.6 kΩ ○

$I = \frac{V}{R}$ ∴ $\frac{V_V}{R_V} = \frac{V_R}{R_R}$

$R_R = \frac{18}{2.0} \times R_V = 9 \times 4.0\ k\Omega = 36\ k\Omega$

(Total 1 mark)

10. A 1.0 μF capacitor initially stores 15 μC of charge. It then discharges through a 25 Ω resistor.

What is the maximum current during the discharge of the capacitor?

A 0.60 mA ○

B 1.2 mA ○

C 0.60 A ●

D 1.2 A ○

$Q = CV$

$V = \frac{Q}{C} = \frac{15 \times 10^{-6}}{1.0 \times 10^{-6}} = 15$

$I = \frac{V}{R} = \frac{15}{25} = 0.60$

(Total 1 mark)

11. Which list puts the forces in order of increasing magnitude?

A 2 pN < 2 fN < 2 TN < 2 GN ○

B 2 pN < 2 fN < 2 GN < 2 TN ○

C 2 fN < 2 pN < 2 TN < 2 GN ○

D 2 fN < 2 pN < 2 GN < 2 TN ●

(Total 1 mark)

$f = 10^{-15}$ $p = 10^{-12}$ $G = 10^{9}$ $T = 10^{12}$

12. 1.0 kilowatt-hour (kW h) is equivalent to

A 6.3×10^{18} eV ○

B 6.3×10^{21} eV ○

C 2.3×10^{22} eV ○

D 2.3×10^{25} eV ●

1 kWh = 1000 × 60 × 60
= 3.6×10^{12} J
$\div 1.6 \times 10^{-19} = 2.25 \times 10^{25}$ eV

(Total 1 mark)

13. Which is equivalent to the ohm?

A J C^{-2} s^{-1} ○

B J C^{-2} s ●

C J s ○

D J s^{-1} ○

$R = \frac{V}{I} = \frac{E/Q}{Q/t} = \frac{Et}{Q^2} \therefore \frac{Js}{C^2}$

(Total 1 mark)

14. What is a correct unit for the area under a force–time graph?

A N m ○

B kg m s^{-1} ●

C kg m s^{-2} ○

D N s^{-1} ○

$Ft = \Delta p \therefore$ kg m s^{-1}

(Total 1 mark)

15. Two gamma photons are produced when a muon and an antimuon annihilate each other.

What is the minimum frequency of the gamma radiation that could be produced?

$2\mu \rightarrow 2\gamma$ $\therefore$ 1:1 ratio

$E = hf \quad f = \frac{E}{h}$

A 2.55×10^{16} Hz ○

B 5.10×10^{16} Hz ○

C 2.55×10^{22} Hz ●

D 5.10×10^{22} Hz ○

$E_{rest} = 105.659 \times 10^{6}$ eV
$= 1.69 \times 10^{-11}$ J

$f = \frac{1.69 \times 10^{-11}}{6.63 \times 10^{-34}} = 2.55 \times 10^{22}$ Hz

(Total 1 mark)

16. Photons of wavelength 290 nm are incident on a metal plate. The work function of the metal is 4.1 eV

What is the maximum kinetic energy of the emitted electrons?

A 0.19 eV ●

B 4.3 eV ○

C 6.9 eV ○

D 8.4 eV ○

$E_{k(max)} = hf - \phi = \frac{hc}{\lambda} - \phi$

$= \left(\frac{6.63 \times 10^{-34} \times 3.0 \times 10^{8}}{290 \times 10^{-9}} \div 1.60 \times 10^{-19}\right) - 4.1$

$= 0.187$

J to eV

(Total 1 mark)

17. A diffraction grating has 500 lines per mm. When monochromatic light is incident normally on the grating the third-order spectral line is formed at an angle of 60° from the normal to the grating.

What is the wavelength of the monochromatic light?

$d \sin\theta = n\lambda$

$d = \frac{1 \times 10^{-3}}{500} = 2.00 \times 10^{-6}$

A 220 nm ○

B 580 nm ●

C 960 nm ○

D 1700 nm ○

$\lambda = \frac{d \sin\theta}{n} = \frac{2.00 \times 10^{-6} \times \sin 60}{3}$

(Total 1 mark)

$= 5.77 \times 10^{-7}$
$= 577 \times 10^{-9}$
$= 577$ nm

18. A mobile phone operates at a constant power of 200 mW
It has a 3.7 V lithium-ion battery that has a charge capacity of 9400 C

What is the time taken for the battery to discharge completely?

A 2 hours ○

B 48 hours ●

C 120 hours ○

D 140 hours ○

$V = \frac{E}{Q}$ $E = VQ = 3.7 \times 9400$
$= 3.478 \times 10^4$ J

$P = \frac{E}{t}$ $t = \frac{E}{P} = \frac{3.478 \times 10^4}{200 \times 10^{-3}}$
$= 173\,900$ s
$\div 3600 = 48.3$ hours

(Total 1 mark)

19. During a single fission event of uranium-235 in a nuclear reactor the total mass lost is 0.23 u. The reactor is 25% efficient.

How many events per second are required to generate 900 MW of power?

A 1.1×10^{14} ○

B 6.6×10^{18} ○

C 1.1×10^{20} ●

D 4.4×10^{20} ○

$E_{single} = 0.23 \times 931.5 \times 10^6 \times 1.6 \times 10^{-19}$
$= 3.428 \times 10^{-11}$ J

$0.25 \times 3.428 \times 10^{-11} \times N = 900 \times 10^6$
$N = 1.05 \times 10^{20}$

(Total 1 mark)

20. What **cannot** be used as a unit for the Young modulus?

A N m^{-2} ○

B Pa ○

C kg m^{-2} s^{-2} ●

D kg m^{-1} s^{-2} ○

$E = \frac{\sigma}{\varepsilon}$

$Pa = Nm^{-2} = kgms^{-2}.m^{-2} = kgm^{-1}s^{-2}$

(Total 1 mark)

21. The units of physical quantities can be expressed in terms of the fundamental (base) units of the SI system. In which line in the table are the fundamental units correctly matched to the physical quantity?

	Physical quantity	Fundamental units	
A	charge	A s^{-1}	○
B	power	kg m^2 s^{-3}	●
C	potential difference	kg m^2 s A^{-1}	○
D	energy	kg m^2 s^{-1}	○

$Q = It \therefore As$

$P = Fv \therefore kg\,m\,s^{-2} \cdot m\,s^{-1}$

$kg\,m^2\,s^{-3}$

$V = E/Q \therefore kg\,m^2\,s^{-2} \div As$

$kg\,m^2\,s^{-3}A^{-1}$

$E = Pt \therefore kg\,m^2\,s^{-3} \cdot s = kg\,m^2\,s^{-2}$

(Total 1 mark)

22. Which of the following is **not** a unit of power?

A N m s^{-1} ○

B J s ● ← $E = P/t \therefore Js^{-1}$

C W ○

D kg m^2 s^{-3} ○

(Total 1 mark)

23. The gravitational constant, G, is a constant of proportionality in Newton's law of gravitation. The permittivity of free space, ε_0, is a constant of proportionality in Coulomb's law.

When comparing the electrostatic force acting on a pair of charged particles to the gravitational force between them, the product $\varepsilon_0 G$ can appear in the calculation.

Which is a unit for $\varepsilon_0 G$?

A $C^2\,kg^{-2}$

B $C^2\,m^{-2}$

C F kg^2 N^{-1} m^{-2}

D it has no unit

$F_g = \frac{G m_1 m_2}{r^2}$ $\quad F_E = \frac{Q_1 Q_2}{4\pi\varepsilon_0 r^2}$

$Fr^2 = G m_1 m_2$ $\quad Fr^2 = \frac{Q_1 Q_2}{4\pi\varepsilon_0}$

(Total 1 mark)

$G m_1 m_2 = \frac{Q_1 Q_2}{4\pi\varepsilon_0}$ $\quad \varepsilon_0 G = \frac{1}{4\pi} \cdot \frac{Q_1 Q_2}{m_1 m_2}$ $\quad \therefore \frac{C^2}{kg^2} = C^2 kg^{-2}$