Higher Physics

Staff Member:

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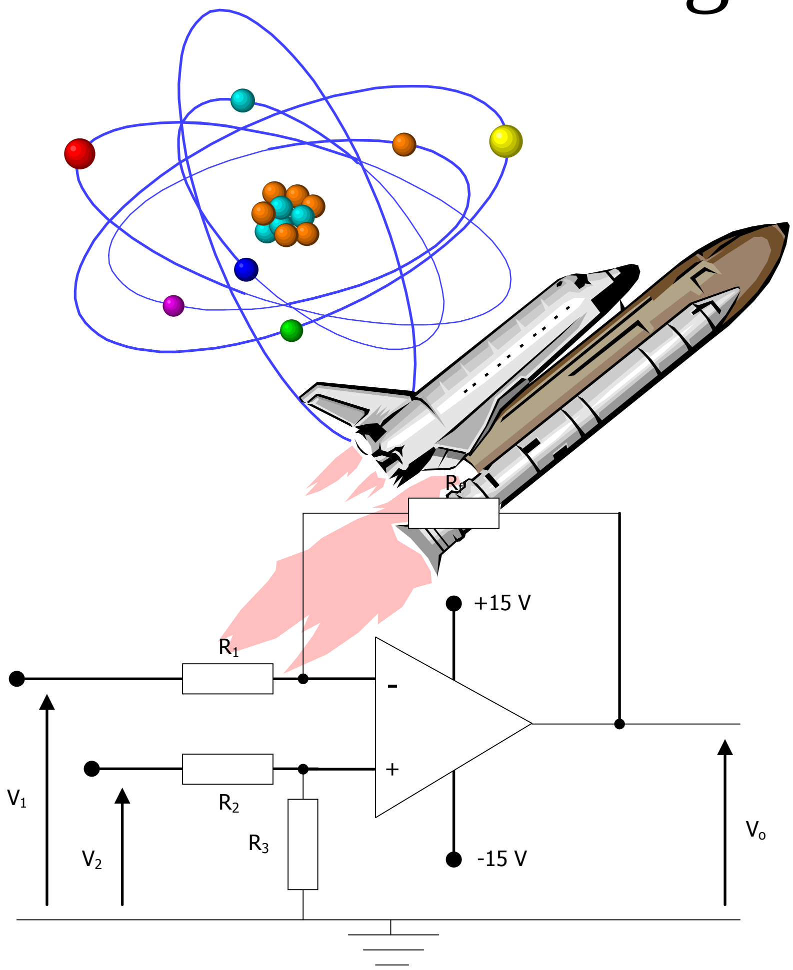
Physics Department

Unit Homework Answers Package



- Uncertainties & Significant Figures - 2 Answer Files
- Mechanics & Properties Of Matter - 6 Answer Files
- Electricity & Electronics - 6 Answer Files
- Radiation & Matter - 6 Answer Files

HOMEWORK MARKING SCHEME
Induction - Uncertainties & Significant Figures

Homework 1 - Significant Figures, Prefixes & Scientific Notation

1. (a) 11.9 V (½)
   (b) 51 Hz (½)
   (c) 0.000000712 m (½)
   (d) 3.0×10^8 ms^{-1} (½)

2. Calculate the following quantities from the information given, and report your answer to an appropriate number of significant figures. Remember to give your answer in scientific notation!

   (a) $f = {}^{v}/_{\lambda} = 9.7 \times 10^9$ Hz (½ each for equation, answer & correct number of sig figs)
   (b) $E = Pt = 1.4 \times 10^5$ J (½ each for equation, answer & correct number of sig figs)

3. Each correct answer is worth (½). (2)

QUANTITY	VALUE	SCIENTIFIC NOTATION
Speed of light	*300 000 000 ms^{-1}*	3×10^8 ms^{-1}
Charge on an electron	0.000 000 000 000 000 000 160 C	*1.60×10^{-19} C*
Wavelength of red light	*0.000 000 7 m*	7×10^{-7} m
Voltage used in the Super Grid	250 000 V (to 3 sig figs)	*2.50×10^5 V*

4. (a) 6 μm (½)
   (b) 1.5 GHz (½)
   (c) 3.2 kW (½)
   (d) 8 mg (½)
   (e) 2.7 MJ (½)
   (f) 742 nm (½)

TOTAL 10 MARKS

Homework 2 - Uncertainties

1. (a) I = 0.48 ± 0.02 A (1)
   V = 1.2 ± 0.1 V (1)

   (b) R = 2.5 Ω (½)
   Percentage uncertainty in current = $^{0.02}/_{0.48}$ x 100 = 4% (½)
   Percentage uncertainty in voltage = $^{0.1}/_{1.2}$ x 100 = 8% (½)
   The best estimate for the uncertainty in the resistance is also 8%, as this is the greatest uncertainty. (1)
   R = 2.5 ± 0.2 Ω. (½)

   (c) mean = $^{\text{sum of values}}/_{\text{number of values}}$ = $^{(0.44 + 0.43 + 0.45 + 0.42 + 0.44)}/_{5}$ = 0.436 (1)

   Uncertainty in mean = $^{\text{max value – min value}}/_{\text{number of readings}}$ = $^{(0.45 – 0.42)}/_{5}$ = 0.006 (1)

   Mean current = 0.44 ± 0.01 A (1)

   (d) The digital meter is more uncertain – twice as uncertain, in fact. (1)
   This is because digital meters have an uncertainty of ± the smallest digit (±0.1 A), whilst analogue meters have an uncertainty of ± half the smallest scale division (±0.05 A). (1)

TOTAL 10 MARKS

Homework 3 - Vectors

1. (a) A vector has both a magnitude and a direction, and a scalar has a magnitude only. (1)
   (b) ***VECTOR:*** *displacement, velocity, acceleration, force, weight, momentum.*
   SCALAR: *distance, speed, time, energy, mass.* (1)

2. 13 ms^{-1} at 23° to the direction of the ferry (or 67° to the direction of the river). (2)
   (1 mark for the magnitude, 1 mark for the direction)

3. $F_x = F \cos \theta = 250 \cos 40 = 191.5$ N (1)
   $F_y = F \sin \theta = 250 \sin 40 = 160.7$ N (1)

4. (a) Total distance travelled = 290 m. (1)
   (b) Footballer's displacement at point D is 50 m West (or 270°) (1)
   (c) $v = \frac{s}{t} = \frac{50}{50} = 1$ ms^{-1} West (or 270°) (2)

TOTAL 10 MARKS

Homework 4 - Equations Of Motion

1. | | | |
|---|---|---|
| $u = ?$ | $s = ut + \frac{1}{2}at^2$ | (½) |
| $v =$ | | |
| $a = -9.8\ ms^{-2}$ | $-2 = 0.6u - 4.9 \times 0.36$ | (½) |
| $s = -2\ m$ | | |
| $t = 0.6\ s$ | $u = 0.39\ ms^{-1}$ | (1) |

2. (a) $v_x = 20 \cos 30 = 17.3\ ms^{-1}$ (1)
$v_y = 20 \sin 30 = 10\ ms^{-1}$ (1)

(b)

$u = 10\ ms^{-1}$	$v^2 = u^2 + 2as$	(½)
$v = 0\ ms^{-1}$		
$a = -9.8\ ms^{-2}$	$0 = 100 - 19.6s$	(½)
$s = ?$		
$t =$	$s = 5.1\ m$	(1)

(c)

VERTICAL	*HORIZONTAL*
$u = 10\ ms^{-1}$	$v = 17.3\ ms^{-1}$
$v =$	$s = ?$
$a = -9.8\ ms^{-2}$	$t =$
$s = 0\ m$	
$t =$	

For time, use vertical motion.
$s = ut + \frac{1}{2}at^2$ (½)
$t = 2.04\ s$ (1)

For range, use horizontal motion
$s = vt$ (½)
s = 35.3 m (1)

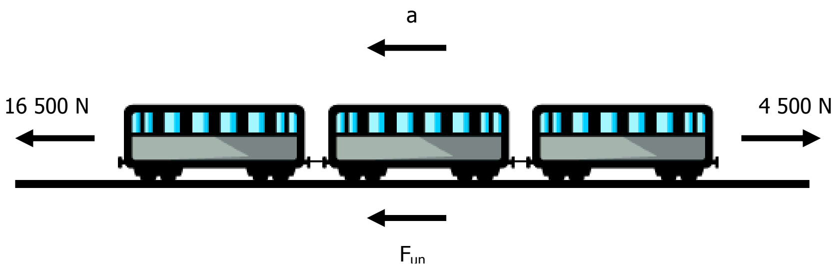
(d) There would be air resistance, which would reduce the horizontal speed. (1)

TOTAL 10 MARKS

HOMEWORK MARKING SCHEME
Mechanics & Properties of Matter

Homework 5 - Forces

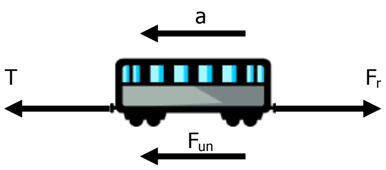
1. (a)



$\mathbf{F_{un} = F_1 - F_2}$ (½)
F_{un} = 16 500 N - 4500 N
F_{un} = 12 000 N (½)

$\mathbf{a = F_{un} / m}$ (½)
a = 12 000 / 24 000
a = 0.5 ms^{-2} (½)

(b)

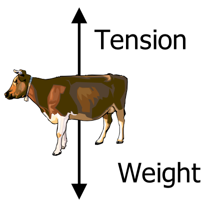


$\mathbf{F_{un} = ma}$ (½)
F_{un} = 8000 x 0.5
F_{un} = 4000 N (½)

$\mathbf{F_{un} = F_1 - F_2}$ (½)
F_{un} = Tension - Friction
4000 = Tension - 1500
Tension = 5500 N (½)

2. (a) $\mathbf{F_{un} = F_1 - F_2}$ = F_{engine} - Weight of cow = 1100 N (1)
$\mathbf{a = F_{un} / m}$ = 1100 / 2000 = 0.55 ms^{-2} (1)

(b) (1)



(c) $\mathbf{F_{un} = ma}$ = 500 x 0.55
F_{un} = 275 N (1)

$\mathbf{F_{un} = F_1 - F_2}$ = Tension - Weight of cow
275 = Tension - 4900
Tension = 5175 N (1)

3. $\boldsymbol{W_{parallel} = mg \sin \theta}$ (½)
$W_{parallel} = 24 \times 9.8 \sin 30$
$W_{parallel} = 117.6\ N$ (½)

TOTAL 10 MARKS

Homework 6 - Momentum and Impulse

1. (a)

TMB = $\mathbf{m_1v_1 + m_2v_2}$
= (110 x 5) + (85 x -7)
= 550 - 595
= -45 $kgms^{-1}$ (½)

TMA = $\mathbf{m_3v_3}$
= 195 x V
= 195V $kgms^{-1}$ (½)

By the conservation of momentum,
total momentum before the collision = total momentum after the collision (½)

-45 = 195V
V = -0.23 ms^{-1} (½)

Final velocity is 0.23 ms^{-1} in the direction of the back.

(b)

E_k Before = $\mathbf{½m_1v_1^2 + ½m_2v_2^2}$
= (½ x 110 x 5^2) + (½ x 85 x -7^2)
= 1375 + 2082.5
= 3457.5 J (½)

E_k After = $\mathbf{½m_3v_3^2}$
= ½ x 195 x 0.23^2
= 5.16 J (½)

Kinetic energy is lost in the collision. (½)
Therefore the collision is **inelastic**. (½)

2. The seatbelt stretches a little, and so the person's change in momentum is spread over a longer time period. (1)
From Ft = Δmv, a longer time of contact leads to a smaller average force (and so a less damaging deceleration for the driver!) (1)

3. **Ft = m(v - u)** (½)
0.05F = 0.1 (-40 - 20) (½)
0.05F = -6
F = -120 N (1)

4. Impulse = area under a force-time graph (½)
Impulse = ½ x 0.08 x 100
Impulse = 4 Ns (½)

Change in momentum = Impulse, so Δmv = 4 $kgms^{-1}$ (½)
mv – mu = 4
(0.1 x v) – (0.1 x 0) = 4
0.1v = 4
v = 40 ms^{-1} (½)

TOTAL 10 MARKS

Homework 7 - Pressure And Density

1. (a)
$1\ m^2 = 10\ 000\ cm^2$

$1\ cm^2 = 1/10\ 000 = 1 \times 10^{-4}\ m^2$ (1)

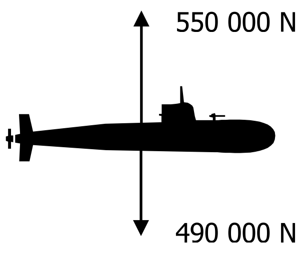
(b)
$\mathbf{P} = {}^{\mathbf{F}}/_{\mathbf{a}}$ (½)
$= (60 \times 9.8) / (4 \times 1 \times 10^{-4})$ (½)
$= 588 / 4 \times 10^{-4}$
$= 1\ 470\ 000$ Pa (1)

(c)
$\mathbf{P} = {}^{\mathbf{F}}/_{\mathbf{a}}$
$= (60 \times 9.8) / 1 \times 10^{-4}$
$= 588 / 1 \times 10^{-4}$
$= 5\ 880\ 000$ Pa (1)

2. $\rho = {}^{m}/_{V}$ (½)
$m = \rho V$
$= 8000 \times (0.02 \times 0.02 \times 0.02)$ (½)
$= 8000 \times 8 \times 10^{-6}$
$= 0.064$ kg (64g) (1)

3. (a) $\mathbf{P} = \rho \mathbf{gh}$ (½)
$= 1000 \times 9.8 \times 500$ (½)
$P = 4\ 900\ 000$ Pa (4 900 kPa) (1)

(b) The weight of the submarine is 490 000 N ($W = mg$), and the upthrust is 550 000 N. (1)
This means there is an unbalanced upward force, so the submarine will rise to the surface. (1)



TOTAL 10 MARKS

Homework 8 - Gas Laws

1. (a) $\frac{P_1}{T_1} = \frac{P_2}{T_2}$ (½)

$\Rightarrow \frac{240}{278} = \frac{P_2}{308}$ (1)

$\Rightarrow P_2 = {}^{240 \times 308}/_{278} = 266$ kPa (½)

(b) When the temperature rises, the **average kinetic energy** of the molecules rises. (½)
This means their **velocity** rises. (½)
The molecules hit the walls of the tyres **harder** and **more often**. (1)

2. $\frac{V_1}{T_1} = \frac{V_2}{T_2}$ (½)

$\Rightarrow \frac{0.5}{273} = \frac{V_2}{295}$ (1)

$\Rightarrow V_2 = {}^{0.5 \times 295}/_{273} = 0.54\ m^3$ (½)

3. (a) $P_1V_1 = P_2V_2$ (½)

$V_2 = {}^{500\,000 \times 15}/_{100\,000}$ (½)

$V_2 = 75$ litres (1)

(b) The gas is at a **constant temperature**. (1)

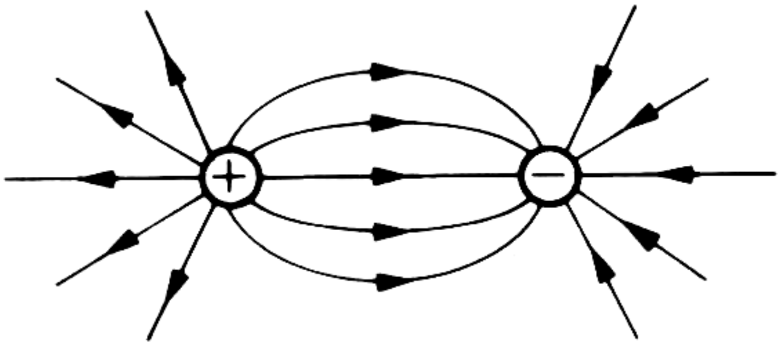
(c) The oxygen tank has a volume, and this will require some gas in it - the astronaut's lungs can't create a complete vacuum in the tank! (1)

TOTAL 10 MARKS

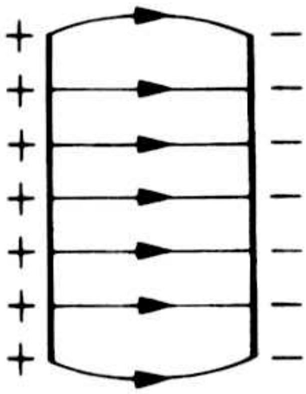
Homework 9 - Electric Fields

1. For each drawing, 1 mark for the lines, and a half-mark for the direction.

   (a)



   (b)



2. A volt is the potential difference between two points which requires that 1 Joule of work is done to move 1 Coulomb of charge between the points. (1)

3. (a) The potential difference between the two plates is 200 V (1)

   (b) W = QV (½)
   W = 1.5 x 200 (½)
   W = 300 J (1)

4. E_k gained = work done by field (½)
   ½ mv^2 = QV (½)
   ½ x 0.001 x v^2 = 0.002 x 100 (1)
   v^2 = (2 x 0.002 x 100)/ 0.001
   v^2 = 400
   v = 20 ms^{-1} (1)

TOTAL 10 MARKS

HOMEWORK MARKING SCHEME
Electricity & Electronics

Homework 10 - Resistors, EMF & Internal Resistance

1. (a) 7.5 Joules per coulomb (1)
   (b) The current through the 10 Ω resistor is the same as the current through all parts – it is a series circuit.
   $I = {}^{E}/_{R} = {}^{7.5}/_{15} = 0.5$ A. (1)
   (c) $V_R = IR = 0.5 \times 10 = 5$ V (2)

2. (a) EMF = 5 V (open circuit potential difference) (1)
   (b) $I = {}^{V}/_{R} = {}^{3}/_{15} = 0.2$ A. (1)
   (c) $E = V + Ir$ (½)
   $5 = 3 + 0.2r$ (½)
   $2 = 0.2r$
   $r = 10\ \Omega$ (1)

3. $R_T = 8$ kΩ (2)

TOTAL 10 MARKS

HOMEWORK MARKING SCHEME
Electricity & Electronics

Homework 11 - Wheatstone Bridges

1. (a) A balanced Wheatstone Bridge is one where the ratio of the resistors is the same on each branch, and hence the potential difference measured by the voltmeter is zero. Accept also $\frac{R_1}{R_2} = \frac{R_3}{R_4}$ (1)

   (b) $\frac{R_1}{R_2} = \frac{R_3}{R_4}$ (½)

   $^{15}/_{30} = {}^{75}/_{R}$ (½)

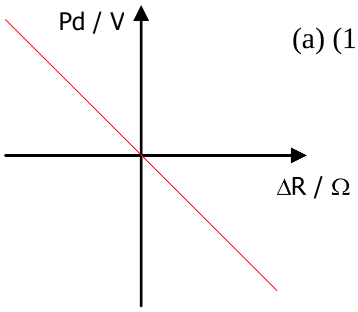
   R = 150 kΩ (1)

   (c) The larger battery makes **no** difference. (1)
   This is because the balance condition is only dependent on the ratios of the 4 resistors. (1)

   (d) There will be a ($^{15}/_{45}$ x 3) V drop over the 15 kΩ resistor… = 1 V (1)
   There will be a ($^{75}/_{150}$ x 3) V drop over the 75 kΩ resistor… = 1.5 V (1)

   The Pd on the voltmeter will be (1.5 – 1) = 0.5 V (1)

2.



(a) (1 mark)

(b) (1 mark)

(2)

TOTAL 10 MARKS

HOMEWORK MARKING SCHEME
Electricity & Electronics

Homework 12 - AC & Capacitors

1. (a) V_{PEAK} = 2 divisions x 5 V/div = 10 V (1)
   (b) Number of divisions for 1 wave = 4 (½)
   Period of wave = 4 x 5 ms/div = 0.02 s (½)

   $F = {}^{1}/_{Period}$ (½)
   Frequency = 50 Hz (½)

   (c) $V_{RMS} = V_{PEAK} \div \sqrt{2}$ = 7.07 V (1)

2. (a) Q = CV (½)
   = $2000 \times 10^{-6} \times 6$ (½)
   = 0.012 C (1)

   (b) E = ½QV (½)
   = ½ x 0.012 x 6 (½)
   = 0.036 J (1)

   (b) E = $\frac{1}{2}CV^2$ (½)
   = $\frac{1}{2} \times 2000 \times 10^{-6} \times 12^2$ (½)
   = 0.144 J (1)

TOTAL 10 MARKS

HOMEWORK MARKING SCHEME
Electricity & Electronics

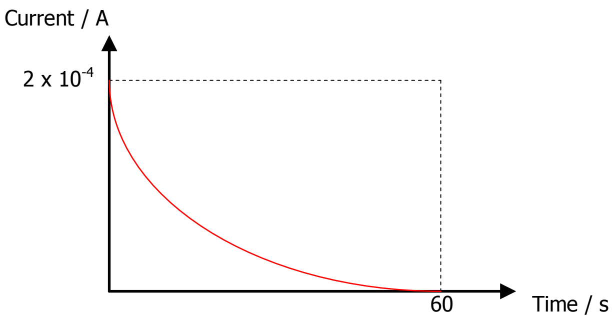
Homework 13 - Capacitors in Circuits

1. (a) As the capacitor is discharged at this point, all 6V are over the resistor.

$I = {}^{V}/_{R}$ (½)
$= 6/30\,000$ (½)
$= 2 \times 10^{-4}$ A (or 0.2 mA) (1)

(b) No current flows when it is fully charged (0 A) (1)

(c) (½) for axes; (½) for each value; (½) for the curve (2)



(d) 6 V (1)

(e) The current discharges through the 50 kΩ resistor. (2)

$I = {}^{V}/_{R}$ (½)
$= 6/50\,000$ (½)
$= 1.2 \times 10^{-4}$ A (or 0.12 mA) (1)

(f) The discharge time would be longer than 60 seconds. (1)
This is because the discharge current is smaller than the charging current. (1)

TOTAL 10 MARKS

Homework 14 - Analogue Electronics

1. (a) Inverting mode. (1)

   (b) $\frac{V_o}{V_i} = -\frac{R_f}{R_1}$ (1)

   (c) -12 V, and 4 V (1 + 1)

   (d) The output gets saturated, or the op-amp cannot output a greater voltage than its supply voltage. (1)

2. (I) There is no potential difference between the two inputs of an op-amp (1)
   (II) The inputs have infinite resistance. (1)

3. (a) $V_o = (V_2 - V_1)\frac{R_f}{R_1}$ (1)

   The ratio of $R_f : R_1$ must be equal to the ratio of $R_3 : R_2$ (1)

   (b) $V_o = 1$ V (1)

TOTAL 10 MARKS

Homework 15 - Waves

1. (a)

Path Difference = $n\lambda$ (½)
1310 - 788 = $2 \times \lambda$ (½)
522 = 2λ
λ = 261 m (1)

(b) The waves are **in phase**. A maximum happens when two crests meet/when you have constructive interference. (1)

2. (a) An interference pattern is seen on screen – a series of blue lines. (1)

(b) The interference pattern spreads out (and is now red lines!) (1)
This happens because red light has a longer wavelength than blue light. (1)

(c) $d = {}^{0.001}/_{100} = 1 \times 10^{-5}$ m (½)

For first order maximum:
$d \sin\theta = n\lambda$ (½)
$\sin\theta = 1 \times (700 \times 10^{-9}) / (1 \times 10^{-5})$ (½)
$= 0.07$
$\theta = 4°$ (½)

For second order maximum:
$d \sin\theta = n\lambda$
$\sin\theta = 2 \times (700 \times 10^{-9}) / (1 \times 10^{-5})$ (½)
$= 0.14$
$\theta = 8°$ (½)

Angle between first order and second order maxima = 8° - 4° = <u>4°</u> (1)

TOTAL 10 MARKS

Homework 16 – Refraction of Light

1. (a) $n = \sin\theta_1 / \sin\theta_2$ (½)
$n = {}^{\sin 55}/_{\sin 35}$ (½)
$= 1.43$ (1)

(b) $n = \lambda_1 / \lambda_2$ (½)
$1.43 = 700 \times 10^{-9} / \lambda_2$ (½)
$\lambda_2 = 490$ nm (or 4.90×10^{-7} m) (1)

(c) Refractive index is frequency dependent. Blue has a higher frequency, so the refractive index of the plastic will be higher for the blue light. This means that the ray will refract more – the angle of refraction will be smaller. (1)

2. (a) $\sin\theta_c = {}^1/_n$ (½)
$\sin\theta_c = {}^1/_{2.42}$ (½)
$\sin\theta_c = 0.41$
$\theta_c = 24.4°$ (1)

(b) The critical angle is the angle where light will no longer be refracted. Beyond this angle, the light will be totally internally reflected. (1)

3. (a) Refractive index is frequency dependent. Each colour has a different frequency and so is refracted by a different amount. (1)

(b) Violet, Blue, Green, Yellow, Orange, Red. (Blue, green, red will do) (1)

TOTAL 10 MARKS

HOMEWORK MARKING SCHEME
Radiation & Matter

Homework 17 - Optoelectronics

1. (a) $E_o = hf_o$ (½)

$3 \text{ x } 10^{-19} = 6.6 \text{ x } 10^{-34} \text{ x } f_o$ (½)

$f_o = 4.5 \text{ x } 10^{14}$ Hz (1)

(b) $f = {}^{v}/_{\lambda}$ (½)

$f = 3 \text{ x } 10^{8} / 400 \text{ x } 10^{-9}$

$f = 7.5 \text{ x } 10^{14}$ Hz (½)

As the frequency of the radiation is higher than the threshold frequency, the photoelectric effect will occur. (1)

(c) $E_k = E - E_o$ (½)

$E_k = hf - E_o$

$E_k = (6.6 \text{ x } 10^{-34} \text{ x } 7.5 \text{ x } 10^{14}) - 3 \text{ x } ^{10-19}$

$E_k = 1.95 \text{ x } 10^{-19}$ J (½)

2. (a) 6 (1)

(b) The maximum frequency occurs when there is the largest energy transition.

$E_3 - E_o = hf$ (½)

$20 \text{ x } 10^{-19} = 6.6 \text{ x } 10^{-34} \text{ x } f$ (½)

$f = 3.0 \text{ x } 10^{15}$ Hz (1)

(c) This would be in the ultraviolet part of the spectrum. (1)
The frequency is higher than that of blue light (answer in part (b)). (1)

TOTAL 10 MARKS

Homework 18 - Semiconductors

1. (a) p-type: ***holes*** (½)
n-type: ***electrons*** (½)

(b) Depletion zone; depletion area (1)
It has no charge carriers. (1)

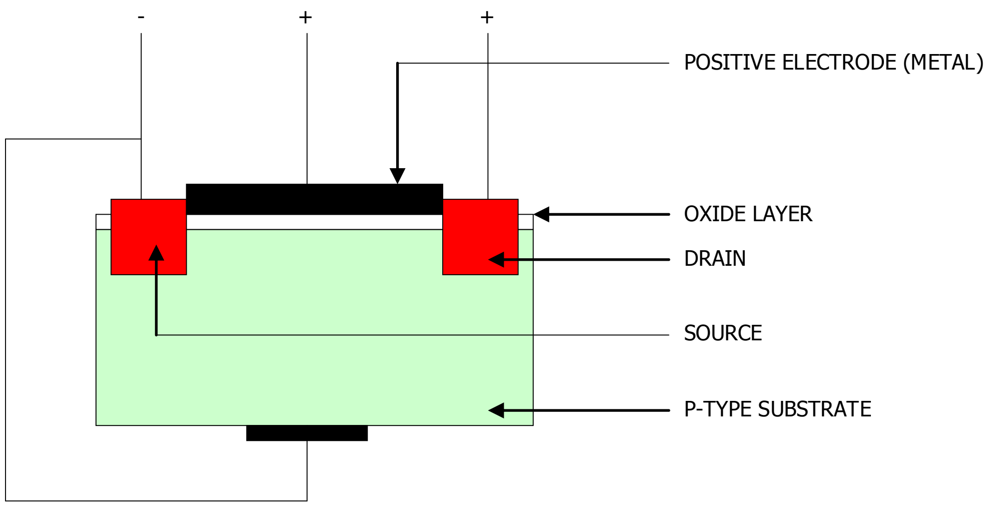
(c) Photoconductive mode and photovoltaic mode (½ each)

Photoconductive mode is where the photodiode is reverse biassed. As the light level increases, more charge carriers are created in the depletion zone, and the resistance of the photodiode decreases. (1)

Photovoltaic mode is where the photodiode is used without an additional battery. Photons produce electron-hole pairs, and this creates a potential difference over the depletion zone. The light produces a votlage. (1)

2. (a) This is a MOSFET. (½)

(b) (½) for each correct answer (2½)



(c) The positive electrode pulls electrons towards it, but they can't pass through the oxide layer. This means they gather in the area between the source and the drain. Electrons can flow along this channel from source to drain. (1)

TOTAL 10 MARKS

HOMEWORK MARKING SCHEME
Radiation & Matter

Homework 19 - Nuclear Reactions

1. (a) Thin gold foil. (1)

   (b) The nucleus was:
   tiny (½)
   positive (½)
   massive (½)

   (c) ***tiny*** - most of the alpha particles were undeflected. (½)
   positive - the positive alpha particles were sometimes repelled backwards. (½)
   massive - the gold nucleus wasn't deflected – the alpha particles were. (½)

2. (a) **Induced** fission reaction (½ + ½)

   (b) ***X*** = 52 ***Y*** = 100 (½ + ½)

   (c) **MASS BEFORE** (½)

   = 239.0512 + 1.0087
   = 240.0599 u

   MASS AFTER (½)

   = 137.0000 + 99.9066 + 1.0087 + 1.0087 + 1.0087
   = 239.9327 u

   MASS LOST (½)

   = 240.0599 – 239.9327
   = 0.1272 u

   MASS CONVERSION (½)

   = $0.1272 \times 1.66 \times 10^{-27}$
   = 2.1×10^{-28} kg

   ENERGY RELEASED

   $E = mc^2$ (½)
   $E = 2.1 \times 10^{-28} \times 9 \times 10^{16}$ (½)
   $E = 1.90 \times 10^{11}$ J (1)

TOTAL 10 MARKS

HOMEWORK MARKING SCHEME
Radiation & Matter

Homework 20 - Dosimetry & Safety

1. (a) For neutrons:

$H = DW_R$ (½)
$= 0.2$ mGy x 10
$= 2$ mSv (½)

For alpha:

$H = DW_R$
$= 15\ \mu$Gy x 20
$= 0.3$ mSv (½)

For gamma:

$H = DW_R$
$= 1$ mGy x 1
$= 1$ mSv (½)

Total equivalent dose = 3.3 mSv (1)

(b)

$\dot{H} = H/t$ (½)
$= 3.3 \times 10^{-3} / 150$
$= 22\ \mu Sv\ h^{-1}$ (½)

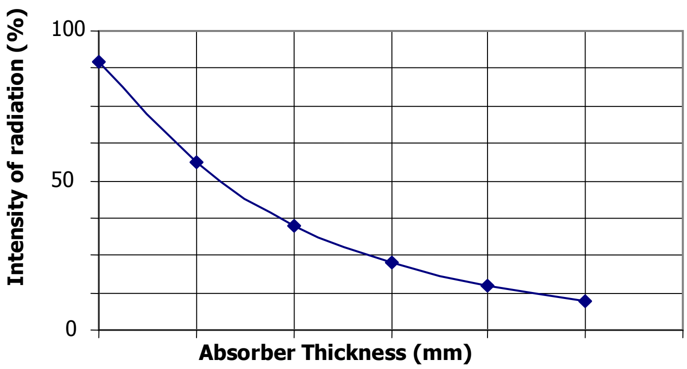
2. (a) Cosmic rays, rocks, all organic material, radon gas (any 2, ½ each)

(b) 5 mSv (although HSE guidelines state 1 mSv) (1)

3. Size of dose, type of organ, type of radiation (any 2, ½ each)

4. 9.9 mm = 3 half-value thicknesses. (½)
equivalent dose rate halves 3 times (½)
$16 \rightarrow 8 \rightarrow 4 \rightarrow 2$ (½)
rate outside box is 2 $\mu Sv\ h^{-1}$ (½)

5. (1)



TOTAL 10 MARKS