P2 – Density

2016 Q3 – the correct answer is D:
This is a displacement question. However, 2 solid objects are placed here. The volume of displacement is: 350 – 250 = 100.
The mass of water initially: 170 – 20 = 150g ; The mass of the object (when singly placed): 470 – 170 = 300g.
When 2 objects added – mass: 2(300) = 600 mass overall: 600 + 170 = 770g
Difference in mass (from 0 solids 2 solids): 770 – 170 = 600
Density = Mass/Volume = 600 / 100 = 300 / 50

P3 – Magnetism

2016 Q11 – the correct answer is B: Rotating the coil at a faster **constant** speed, increases the induced voltage produced. Hence, it leads to an increase in **amplitude** of the oscilloscope graph. This is as, a large voltage corresponds to the y axis. As the coil rotates at a faster speed, voltage is induced at a faster **rate**, hence the time period **decreases**, as voltage is being induced faster due to faster relative motion. This **increases** the **frequency** of the induced voltage, hence more waves are observed on the oscilloscope graph.

P4 – Waves

2016 Q15 – the correct answer is D: Microwaves are used for satellite communication.
Total distance = 2 (45000 x 1000) = 9×10^7m
Speed = Distance/Time
$9 \times 10^7/(3 \times 10^8) = 0.30$s
The frequency given is irrelevant, as it does not partake in the calculation.

2016 Q27 – the correct answer is C: Frequency does **not change** when a light travels through a medium. Hence, the frequency of light through water should be calculated first:
$c=f\lambda$; $3/4 \times (3 \times 10^8) = 2.25 \times 10^8$ $2.25 \times 10^8 = (360 \times 10^{-9}) \times f$
$f = 2.25 \times 10^8 / 360 \times 10^{-9} = 6.25 \times 10^{14}$
Glass: $2/3 \times (3 \times 10^8) = 2 \times 10^8$ $2 \times 10^8 / 6.25 \times 10^{14} = 3.2 \times 10^{-7} = 320$ nm

2015 Q3 – the correct answer is B: Black coated surfaces are the best absorbers and emitters of infrared radiation. In order to keep a person warm in the winter,

infrared radiation needs to be prevented from being **emitted from the person.** White is the **worst** emitter and absorber of infrared radiation, and so restricts heat lost.

2014 Q19 – the correct answer is C: Period= 2s hence, frequency =(1/ 2) = 0.5 Hz
$v = f \times \lambda = 0.50 \times 1.5 = 0.75$cm/s

2014 Q3 – the correct answer is D: Statement 1 is **incorrect**; microwaves have a **longer wavelength** than infrared radiation and many other parts of the electromagnetic spectrum. Statement 2 is **incorrect**; energy increases with frequency (and consequently decreases with wavelength), and so in fact the **shortest wavelengths** transfer the **most** energy. Statement 3 is **incorrect**; the wavelength is **inversely proportional** to frequency, and the **speed** is the **constant** for this relationship ($v = f \times \lambda$). Statement 4 is **correct**; ultraviolet waves are **higher frequency** than visible light, so carry **more** energy and can damage corneas, causing cataracts.

2013 Q11 – the correct answer is C: In Diagram 1, refraction occurs, as the light travels from a dense to a less dense medium. Most of the light is refracted in the direction of P, however, some internal reflection occurs. No T.I.R occurs, as the 40 < 42, and for T.I.R to occur, the angle of incidence must exceed the critical angle.
In Diagram 2, the light follows the direction of S - refraction. This is as, the light travels from a more dense to a less dense medium. Although 45 > 42, the critical angle, the condition for T.I.R is that light travels from a **more dense** to a **less dense medium.** This is true for Diagram 1, yet the angle of incidence in that case doesn't conform. In Diagram 2, the medium transfer is opposite.

2013 Q3 – the correct answer is D: Statements 1 and 2 are correct only.
Microwaves can be absorbed by water molecules in your body, which can lead to damage. X rays cause ionisation, in which electrons off DNA molecules are released due to the energy of X-rays. This can cause DNA mutations, leading to cancerous cells. Statement 3 is incorrect, as infrared waves penetrate matter anyways, however this is not the reason for damage. The intensity of infrared waves can lead to damage (i.e. a very hot surface).

2012 Q27 – the correct answer is G: Only the distance and time period are given. Hence, amplitude and wavelength cannot be determined. The frequency can, as we are given the time period (pulses of pressure every 0.2 milliseconds).
F = 1/T. Hence, $1/(0.2 \times 10^{-3}) = 5000$ Hz = 5.0 KHz

2012 Q15 – the correct answer is B: Frequency is invariant, hence use the speed in a vacuum to calculate it: $c=f\lambda$; $f = c/\lambda$ $(3 \times 10^8)/(12 \times 10^{-2}) = 2.5 \times 10^9$

$\lambda = c/f$ (using **new speed**): $(2 \times 10^8)/(2.5 \times 10^9) = 0.08$ m = 8 cm

2011 Q23 – the correct answer is C: Frequency is invariant:

$f = c/\lambda$ $(3 \times 10^8) / (600 \times 10^{-9}) = 5 \times 10^{14}$ Hz

(Although not given, in glass the speed of orange light: $2/3 \times 3 \times 10^8 = 2 \times 10^8$)

$\lambda = c/f$ $2 \times 10^8/5 \times 10^{14} = 4 \times 10^{-7} = 400$nm

2011 Q27 – the correct answer is B: Their right foot comes down between each beat. Each beat occurs after 60/50 seconds. The delay is half of the total beat, as it is between two beats, which is 60/100. Distance = Speed x Time = 330 x (60/100) = 198m

2010 Q7 – the correct answer is A: The amplitude is 3, as the total height from maximum to minimum is 16-10 = 6, hence 6/2=3. This is as, amplitude is measured from the equilibrium position. The time period is the length of time from one minimum to another, or one maximum to another. Hence, this time: 12 hours. This expressed in seconds = 12 x 3600s. The Frequency = 1/Time Period = 1/(12 x 3600)

2009 Q27 – the correct answer is E:

The displacement distance graph gives the wavelength of the wave. The wavelength is the distance between peak to peak, or trough to trough of a wave. However, only the total distance is given. There are 2 waves within that distance, and the distance is 60m. Hence, the wavelength = 60/2 = 30.

The displacement time graph gives the time period of the wave. The time of the waves is 0.6s, and there are 3 waves. Hence, the time period: 0.6/3 = 0.2s.

The frequency, is 1/time period. Hence, 1/0.2 = 5.

As $c=f\lambda$, 30 x 5 = 150.

P5 – Electricity

2016 Q19 – the correct answer is D: Energy = Power X Time = Current X Voltage X Time

$125 = 500 \times 10 \times 10^{-3}$ x current

Current = $125/(500 \times 10 \times 10^{-3}) = 250$

2015 Q7 – the correct answer is D: P=VI; as the voltage decreases, the current is increased. Hence, as the voltage decreases and the current increases, the power must remain the same.

2015 Q27 – the correct answer is D: Statement 1 is correct - F = ma 4 x 1.25 = 5
Statement 2 is correct – c= fλ ; 5 = 4 x 1.25
Statement 3 is incorrect – V = IR, As 4 NOT EQUAL to 5 x 1.25

2014 Q7 – the correct answer is F: From power $P = VI$, current $I = P/V$, so unit (ampere) = watt/volt

2014 Q11 – the correct answer is F: Only electrons are transferred when an object becomes **charged**. Hence options C, D, G and H are **all incorrect**. The object becomes **negatively charged** if it **gains electrons** and **positively charged** if it **loses electrons**. For **repulsion** to occur, **two objects** must have **like charges**, so either rod X gained electrons from the cloth and rod Y was negatively charged (which is not one of the options) or rod X lost electrons to the cloth and rod Y was positively charged, option F.

2013 Q7 – the correct answer is H: P, the ammeter, increases, as the current is not shared between the second resistor. Although the arrangement is series, and so current should remain constant in a series circuit, the short circuit causes the effects of a parallel circuit – current sharing – to be observed. The voltmeter Q increases, whereas the voltmeter across R decreases. This is as, short circuiting in R occurs, as the current bypasses the resistor, and flows through the path of the closed switch, as it has less resistance. The voltage is shared in that branch, compared to the branch with the resistor. Hence, the voltage drops in the path of the resistor, as measured by the voltmeter. Q increases, as no voltage is given to the resistor at R, hence more voltage is supplied to Q.
Short circuiting: When a switch, in parallel to a component (in this case a resistor), is closed, the charge carriers prefer the path of least resistance, which in this case is the parallel wire with the switch. Hence, all charge flows through the wire and so none flows through the resistor. Consequently, the voltage measured is minimal. The reverse is true when the switch is open. The charge is forced to go through the resistor, and so the voltage is higher.

2013 Q19 – the correct answer is D: P=IV and V=IR
$P = I(IR) = I^2R$; $I = V/R$; V = emf V , $R = R_1 + R_2$
Hence, $I = V/(R_1 + R_2)$
$P = (V/(R_1 + R_2))^2 \times (R_1 + R_2) = V^2/(R_1 + R_2)$

2012 Q19 – the correct answer is D: Reading on ammeter 1 decreases, as the current cannot pass through the broken lamp, hence the current being received is from the parallel branch. Reading on ammeter 2 increases, as more current flows

through this branch, due to having less resistance – the broken lamp provides resistance for the current, as it's harder for charge carriers to pass through a non-functional conductor. The total resistance of the circuit increases, as the broken lamp acts as a 'resistor', as it opposes the movement of charge carriers.

2011 Q11 – the correct answer is B: The diode only allows movement in one direction, which is from the negative to the positive terminal. A short circuit does not occur here when the switch is closed, as the diode forces the current to travel in its path. Hence, the current is the same regardless of the closure or opening of the switch. R = 3 + 3 = 6. V=IR, I=V/R hence, I = 6/6 =1.0A.

2011 Q19 – the correct answer is A: A resistor at constant temperature, does not alter in resistance, and so according to V=IR, V is proportional to R, and so the voltage also remains constant. If the temperature increases, the resistance increases, as heat causes resistor atoms to vibrate. This leads to more collisions between electrons and resistor atoms, and collisions cause the dissipation of energy of the electrons. Hence, the voltage would decrease in such a case.

2009 Q7 – the correct answer is E: P = VI ; P = watts, I = amps. V = P/I.
Hence, V = watts/amps = watts per amp

P6 – Work, Power and Energy

2016 Q23 – the correct answer is E: W=mg – Mass of the object does not change on any planet, only the weight changes, due to the different gravitational strengths.
M = W/g hence, on Earth: 15/10 = 1.5 kg.
Kinetic energy gained on planet = gravitational energy lost on planet
Mgh = gravitational energy lost (as no velocity is provided, cannot calculate kinetic energy directly, hence we use the conservation of energy). W = mg, hence use 3.0N as mg. Hence, 3 x 10 = 30J

2014 Q15 – the correct answer is B: Cooled water will become more dense and fall, causing a convection current in the container. The cooling unit should be positioned at the top to ensure that all the water is cooled, including the warmer, less dense water at the top. The water starts at room temperature, and will soon become cooler than its surroundings. This means that a dark surface would absorb more infra-red from the surroundings than it would emit. A shiny surface reduces this effect and will help to keep the water cooler than the surroundings.

2014 Q27 – the correct answer is D: Power output in this question is about the change in potential energy (mgh) per unit time. The mass and gravitational field strength are constant, so the change in potential energy with time is directly related to the change in height with time. In the graph we can see that the change in height with time (the gradient) is constant from 15s to 35s (which includes the time at which it is at the height of 10 m). Hence, we can use this as the time interval from which to calculate the power and energy change. The change in height is 10 m (15–5m) in this interval of 20s. This relates to a change in potential energy of 2000 J (mgh = 20×10×10) in the interval. The power output is given by change in potential energy, divided by the time interval: 2000/20 = 100W.

2013 Q27 – the correct answer is E: F = ma for acceleration: a = F/m ; a = 20/4 = 5 ms^{-2}. Use ½mu^2 to find u = initial velocity: ½mu^2 = 1800
½ (4)(u^2) = 1800 u^2 = 90 u = 30
V = u + at. (Where u (initial velocity) = 30). Hence, v = 30 + (2 x 5) = 40
KE = ½mv^2 = ½ x 4 x 40^2 = 3200
Hence, 3200 – 1800 = 1400

2012 Q23 – the correct answer is D:
Loss in gravitational potential = mgh = 100 x 10 x 100 = 100 000J.
At constant speed, the resistive force = weight component parallel to incline
Hence, F = mgH/L
L = incline = 10m
H = change in horizontal = 1m
100 x 10 x 1/10 = 100N

2011 Q3 – the correct answer is C:
Calculate GPE and KE of both cars and compare
GPE
P: mgh = 25mg
Q: mgh = 50mg
Hence, Q has 2xGPE as P
KE
P: ½mv^2 = ½ x m x $(10)^2$ = 50m
Q: ½mv^2 = ½ x m x $(20)^2$ = 200m
Hence, Q has 4xKE as P

2010 Q23 – the correct answer is G: P = E/t
P = mgh/t = 5 x 5 x 10 = 250 (time already included, as passing each second)
Loss of GPE = gain in Ek
Hence, ½mv^2 = 250 ; v = √(2(250)/5) = 10

2010 Q27 – the correct answer is D: Energy + Work Done against frictional force = Total Energy
According to the ratio of 1/20, the vertical height after moving 50m: 1/20 x 50 = 5/2
Hence, GPE = mgh = 800 x 10 x (5/2) = 2000J
Work done to overcome friction = 500N x 50m = 2500J
Hence, 2500 + 2000 = 4500J

2009 Q19 – the correct answer is B: Loss of GPE = gain in Ek
$mgh=1/2mv^2$; $h = ½ (v^2/g) = ½ \times (20)^2/10 = 20$

P7 – Radioactivity

2015 Q11 – the correct answer is A: Neutrons emitted in nuclear fission can cause further fission, as they can be absorbed by more fission fragments, causing them to split up further. Statement 2 is incorrect – the half-life = the time taken for half of the nuclei to decay. Statement 3 is incorrect – nuclear fusion occurs in the Sun, not nuclear fission.

2015 Q19 – the correct answer is G: When a beta particle (electron) is emitted, a neutron turns into a proton, hence the atomic number (proton number) increases, hence W (atomic number of M) + 1 = X (atomic number of X). When an alpha particle is emitted, 2 protons and 2 neutrons are released. Hence, the mass number decreases by 4. (Y = V – 4).

2014 Q23 – the correct answer is B: The total mass number of the particles before fission is 235 + 1 = 236 (uranium + neutron).
As the total mass number is conserved, the total mass number of the particles after fission must also be 236.
E) is the only statement in which the products have a total mass of 236 units.
A) has products with a total mass of 235 units.
B) has products with a total mass of 238 units.
C) has products with a total mass of 235 units.
D) has products with a total mass of 237 units.
F) has products with a total mass of 239 units.

2013 Q15 – the correct answer is D:

2012 Q3 – the correct answer is B: P = N-4, as this is alpha decay. This is as, the atomic (proton) number decreases by 2, and this is only possible via alpha decay.

Alpha decay leads to a loss of 4 nucleons. As P is conserved in Z, there is no change in mass number. The only emission that conserves mass number, is beta (positive – in this case) decay. However, proton number decreases by 1, as a proton turns into a neutron, and releases a positron (antielectron).

2012 Q7 – the correct answer is F: It is definitely not alpha, as alpha is stopped by a piece of paper, and it has a very short range in air, and would be very minimally detected. Beta and gamma pass through paper, however beta is stopped by aluminium. Hence, in aluminium, it is almost only gamma rays.

2012 Q22 – the correct answer is B: If hydrogen undergoes Beta decay, a neutron turns into a proton and the mass number is not changed - still 3. HTO – 1 hydrogen, 1 tritium and 1 oxygen. Hydrogen has atomic number 1, so it has 1 proton in its nucleus.
Helium has atomic number 2, so it has 2 protons in its nucleus.
Tritium is an isotope of hydrogen, so it contains 1 proton.. Since tritium's mass number is 3, a tritium nucleus must also contain 2 neutrons. Hence, tritium is 1 proton and 2 neutrons.
Beta minus decay turns a neutron to a proton (and releases an electron and antineutrino). So after beta minus decay of tritium, the remaining nucleus contains 2 protons and 1 neutron. Hence, it's now an isotope of helium: He - 3
Hence, tritium has turned to helium. T→He
HTO therefore initially becomes HeOH.
But He is a noble (inert) gas, so it is chemically unreactive and does not bind to oxygen or hydrogen
Therefore HeOH OH + HE
Since there is initially 'a quantity' of HTO, a large amount of OH is produced. The OHs will react together as follows:
$4OH \rightarrow 2H_2O + O_2$
So we are left with H_2O, O_2 and He, corresponding to answer choice 2 only.

2011 Q7 – the correct answer is E: E is correct, as the emission of a beta particle is due to a neutron changing into a proton (+ an electron), hence no particles are lost from the nucleus, and the mass number remains the same. All other are incorrect, here are their correct versions:
A – The process of emission of a gamma ray from a nucleus is called gamma radiation
B – The half-life = the time taken for half of the nuclei to decay
C – Neutrons = mass number – atomic number
D – Nuclear fission occurs in power stations

F – In alpha emission, 2 neutrons and 2 protons (helium nucleus) are released from the nucleus

2010 Q3 – the correct answer is A: The mass of uranium gained, corresponds to the mass of protactinium lost. Uranium's final mass is 16mg, and half of this mass is 8mg. At 8mg, the time is 1.2 minutes, corresponding to the half life.

2010 Q11 – the correct answer is C: Mass number: 219 – 3(4) - 2(0) =
219 – 12 = 207
3 alpha particles have 4 nucleons each, hence 3 x 4 = 12, hence 12 nucleons lost.
Beta particles don't cause a change in mass number, as a neutron turns into a proton, hence no change in nucleon number.
Atomic number: 86 – 3(2) + 2(1) = 82
3 alpha particles have 2 protons each, hence 3 x 2 = 6, hence 6 protons lost.
Beta particles change in proton number, as a neutron turns into a proton; as a proton is gained each time, twice, 2 protons are gained.

2009 Q11 – the correct answer is C: The radiation is Beta, as beta particles have a short range in air, a few cm, and a short half life of a few hours too – all values for half life are within the range of 2-3 hours. It cannot be alpha, as the range of alpha is too short – 3-5 cm. For half life: count rate initially = 220. Count rate halved at 110. Graphically, this corresponds to 2.40 hours – it cannot be 2.76 hours, as on the graph, the point is less than halfway. Detector 2 has a constant reading, as the range of beta particles is around 15cm, and so there is a constant rate of minimal beta particles being detected.

P8 – Forces

2016 Q8 – the correct answer is B: 75 = Total mass/N
J+K+L + Total Mass/N+3 = 78
J+K+L/3 = 90
Hence, J+K+L = 270
Substitute this into second equation: 270 + Total Mass /(N+3) = 78
Total Mass (from equation 1): 75N
270 + 75N/(N+3) = 78 78(N+3) = 270 + 75N 78N+234 = 270 + 75N 3N = 36
Hence, N = 12

2015 Q15 – the correct answer is A:
Horizontal acceleration: Resultant force 50N – 40N = 10N
$a = F/m$ 10/2 = $5ms^{-2}$

Vertical acceleration: Resultant force 25N – 20N = 5N UPWARDS
a = F/m 5/2 = 2.5ms^{-2}

2012 Q11 – the correct answer is D: In diagrams 2 and 3, work is being done by force F, however, this occurs at a component of d at an angle θ in Diagram 2. This is as, the work is not being done in the direction of D, yet it is done at an angle in the direction of d. Hence, an appropriate formula would be: W = Fdcosθ
In Diagram 3, work is being done in the direction of the Force and the vertical distance, as the pulley is pulling the weight vertically up, through a vertical distance of f. Diagram 1 - no work is being done by F, as the force is opposed by the resistance of the chair – the force is not actively moving the object in that distance, the object is stationary – it is not a vector due to this stationary nature.

2011 Q15 – the correct answer is B: initial velocity (u) = 300ms^{-1},
final velocity (v) = 0
mass = 0.05kg
Deceleration = 0.6m. As, s= - u^2/2a (from v^2 = u^2 + 2as 0 = u^2 + 2as - u^2 = 2as)
-a = ½ x (300)^2/(2x0.6) = -75000
F=ma
F = (0.05)(-75000) = 3750 N = 3.75 x 10^{3}N

2009 Q3 – the correct answer is C: Resultant Force = 900N – 600N = 300N
Hence, force = upwards. a = F/m ; 300/60 = 5 ms^{-2}

2009 Q23 – the correct answer is A:
F=ma
15000 = (20000+2(5000))a
a=1/2
15000 - T = (20000+5000)a
T = 15000 – 12500 = 2500

P9 – Speed, Distance, Time

2015 Q23 – the correct answer is D:
Distance traveled in reaction time:
s = vt
s = 20(2(0.7))
s = 28 m
Distance traveled while braking:
s = ½ (u+v)t
s = [(20 + 0)/2]x3.3

s = 33 m
Hence, Total distance:
d = 38 + 33
d = 61 m

2010 Q19 – the correct answer is B: Acceleration = velocity/time = gradient of the graph
Hence, for Q: (58-10)/(20-0) = 2.4

2009 Q15 – the correct answer is D: The trapezium (for 1 minute) can be calculated: (15 + (20x60)) x ½ = 607.5
Rectangle: (3x60) x (20) = 3600
Approximate area as triangle: (3x60) x 20/3 = 1200
Hence, 607.5 + 3600 + 1200 = 5407.5m nearest value is 6km

P10 – S.I. Units

2013 Q23 – the correct answer is D: This is as, speed = wavelength x frequency
wavelength = speed/frequency – if y =mx, then this graph would be y=m/x, hence it would give a reciprocal graph, which is not a linear graph, thus it would be incorrect.