Q1(1):

The distance that the car travels=The area under the $v-t$ graph.

$=\frac{(80+(40-20))(60)}{2}$

$=\boxed{3000\ m}$

Q1(2):

Let v_n be the velocity after the nth impact. Then, we have $\frac{v_n}{v_{n-1}}=e$ by the defination of coefficient of restitution. Solving the recurrance, we have $v_n=e^n v_0$.

Set the GPE as 0 at the ground, by the conservation of energy, we have KE+GPE=KE+GPE

$$0+mgh=0+\frac{1}{2}mv_0^2$$

$$v_0=\sqrt{2gh}$$

Then, $v_n=e^n\sqrt{2gh}$ and hence

$$\frac{1}{2}mv_n^2+0=0+mgh_n$$

$$h_n=\boxed{he^{2n}}$$

Q1(3):

The magnetic field strength produced by a straigth wire is given by $\frac{I}{2\pi r}$ and the direction is determined by the right-hand grip rule.

As the distances between P and the wires are $\sqrt{2}d$, we have the magnetic field strengths of the two wires are $\frac{I}{2\sqrt{2}\pi d}$ in directions $N45°W$ and $N45°E$ respectively.

Consider the vector sum of the two magnetic fields, as the angle between the two vectors is $90°$, the magnitude is given by $\sqrt{(\frac{I}{2\sqrt{2}\pi d})^2 + (\frac{I}{2\sqrt{2}\pi d})^2} = \boxed{\frac{I}{2\pi d}}$.

Q1(4):

By the graph, we have $\lambda = 4\ m$.

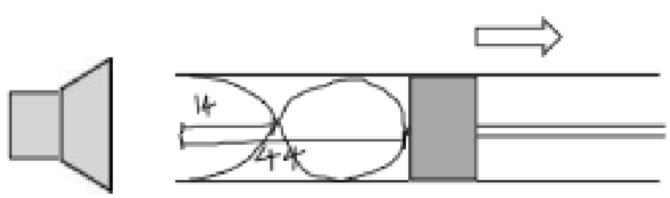
As the amplitude of the sine wave is $3\ m$ by the graph, we have

$y = A \sin \frac{2\pi}{\lambda}(x - vt) = \boxed{3 \sin \frac{\pi}{2}(x - 2t)}$.

Note: Mathematically, A is the amplitude of the sine wave, λ is the period and vt is the displacement in positive x direction.

Q1(5):

Refer to the graph:



We have $\frac{\lambda}{2} = 44 - 14$, i.e. $\lambda = 60\ cm$

Then, $v = f\lambda = 555(0.6) = \boxed{333\ m/s}$.

Q2:

(1): When the capicitor has no charges, it has 0 resistance, i.e. all the voltage are consumed by the resistor.

By the Ohm's law, we have $I_0 = \boxed{\dfrac{V}{R}}$.

(2): When the capicitor is fully charged, it has infinite resistance, i.e. all the voltage are consumed by it.

By the defination of capacitance, we have $Q = \boxed{CV}$.

(3): The work done by the battery during charging=$V\Delta Q = V(CV) = CV^2$.

The internal energy stored in the capacitor=$\frac{1}{2}CV^2$.

There are energy lost in form of heat, which is $CV^2 - \frac{1}{2}CV^2 = \boxed{\dfrac{1}{2}CV^2}$.

(4): We have $I = \frac{dQ}{dt}$.

At the very beginning, the charges are still stored in the capacitor, hence $I = 0\ A$.

As the circuit is an AC circuit (voltages alternative provided by the capacitor and the inductor), the graph of it is hence a sine wave.

As there are no charges lost, the amplitude of the wave should be constant throughout.

Given the above, the appropriate graph is $\boxed{d}$.

Alternative By Lenz' law, the coil will have to produce a magnetic field pointing inside the paper inside the coil so as to oppose the change in magnetic flux. Therefore, by right hand grip rule, the direction of the induced current will be $\boxed{a \to b \to c \to d}$.

(5): The internal energy of the inductor is given by $\frac{1}{2}LI^2$.

When all the internal energy of the capacitor is transferred to the inuctor, the current through the inductor is maximised.

By that time, we have $\frac{1}{2}LI^2 = \frac{1}{2}CV^2$, i.e. $I = \boxed{\sqrt{\frac{C}{L}}V}$.

Alternative (with calculus) We have $V = L\frac{dI}{dt}$, i.e. $\frac{dV}{dt} = L\frac{d^2I}{dt^2}$.

Moreover, we have $Q = CV$, i.e. $\frac{dQ}{dt} = I = C\frac{dV}{dt}$.

Combine the two equation, $\frac{d^2I}{dt^2} - \frac{1}{LC}I = 0$.

Substitue the result of (4), $I = A\sin\omega t$ into the equation, we have $\omega = \frac{1}{\sqrt{LC}}$.

Then, $V = \frac{L}{\sqrt{LC}}A\cos\frac{t}{\sqrt{LC}}$.

As the maximum voltage is equal to the EMF of the battery used for charging the capacitor, we have $V = \sqrt{\frac{L}{C}}A$, i.e. $A = \sqrt{\frac{C}{L}}V$.

Therefore, the maximum value of $I{=}A = \boxed{\sqrt{\frac{C}{L}}V}$.

Q3:

(1): The horizontal velocity is v.

As there is no horizontal acceleration during the motion, the x-coordinate at the time $t = \boxed{vt}$.

(2): The initial vertical velocity is 0 and there is a constant vertical acceleration $-g$.

By $s = ut + \frac{1}{2}at^2$, the vertical displacement at the time $t = -\frac{1}{2}gt^2$.

Therefore, the y-coordinate at the time $t = \boxed{h - \dfrac{1}{2}gt^2}$.

(3): When $y = 0$, $t = \sqrt{\frac{2h}{g}}$.

If the object does not hit the slope, then the x-coordinate of it is greater than $\frac{h}{\tan\theta}$ when $t = \sqrt{\frac{2h}{g}}$.

Then, $v_c(\sqrt{\frac{2h}{g}}) > \frac{h}{\tan\theta}$, i.e. $v_c > \boxed{\dfrac{\sqrt{2gh}}{2\tan\theta}}$.

(4): The parametric equation $\begin{cases} x = vt \\ y = h - \frac{1}{2}gt^2 \end{cases}$ can be rewritten as $y = h - \frac{gx^2}{2v^2}$.

Besides, the equation of the slope is given by $y = -\tan\theta x + h$.

Solving $h - \frac{gx^2}{2v^2} = -\tan\theta x + h$, we have $x = \boxed{\dfrac{2v^2}{g}\tan\theta}$.

Q4:

(1): Consider figure (a), the force due to the atmosphere pressure$=PA$ and the weight of the pistion$=mg$. Therefore, the pressure of the gas inside the cylinder is equal to $\frac{PA+mg}{A}$.

Similarly, the pressure of the gas inside the cylinder for figure (b) is equal to $\frac{PA+(M+m)g}{A}$.

As $p \propto \frac{1}{V} \propto \frac{1}{h}$ for fixed T, we have $h_1 = \boxed{\dfrac{PA+mg}{PA+(M+m)g}h}$.

(2): $W = p\Delta V$

$= P(Ah - Ah_1)$

$= \boxed{\dfrac{MgPAh}{PA+(M+n)g}}$

(3): During the expansion, the pressure of the gas inside the cylinder remains constant. Therefore, we have $T \propto V \propto h$.

Hence, $T' = \boxed{\dfrac{h_2}{h}T}$.

(4): During the compression, the pressure of the gas inside the cylinder remains constant. Therefore, we have $V \propto T$, or $h \propto T$.

Hence, $h_3 = \frac{h}{h_2}h_2 = \boxed{h}$.

Q5:

(1): By the defination of refractive index, we have $n = \frac{c}{v}$.

As the frequency remains constant, we have $n = \frac{\lambda}{\lambda'}$, i.e. $\lambda' = \boxed{\dfrac{\lambda}{n}}$.

(2): By Snells' law, we have $\boxed{\sin\theta = n\sin\phi}$.

(3): Let Q be the starting point of the light way in water (correspondingly, the starting point in air will be C).

Then, the optical path different of the two light rays=$n(QB + BC)$.

As constructive interference occurs, we have the optical path different=$m\lambda$.

However, as the reflection increased the phases different by π, we have the optical path different=$(m + \frac{1}{2})\lambda$.

Given the above, we have $\boxed{QB + BC = (m + \dfrac{1}{2})\dfrac{\lambda}{n}}$.

(4): We have $BC = \frac{d}{\cos\phi}$ and $QB = BC\cos 2\phi$.

Therefore, $QB + BC = BC(1 + \cos 2\phi) = 2BC\cos^2\phi = \frac{2d}{\cos\phi}$.

By the condition in (3), we have $d = \boxed{\dfrac{(2m+1)\lambda}{4n\cos\phi}}$.