NATIONAL SENIOR CERTIFICATE EXAMINATION
NOVEMBER 2011

PHYSICAL SCIENCES: PAPER I

MARKING GUIDELINES

Time: 3 hours 200 marks

These marking guidelines were used as the basis for the official IEB marking session. They were prepared for use by examiners and sub-examiners, all of whom were required to attend a rigorous standardisation meeting to ensure that the guidelines were consistently and fairly interpreted and applied in the marking of candidates' scripts.

At standardisation meetings, decisions are taken regarding the allocation of marks in the interests of fairness to all candidates in the context of an entirely summative assessment.

The IEB will not enter into any discussions or correspondence about any marking guidelines. It is acknowledged that there may be different views about some matters of emphasis or detail in the guidelines, and different interpretations of the application thereof. Hence, the specific mark allocations have been omitted.

QUESTION 1 MULTIPLE CHOICE

1.1 B (2)
1.2 A (2)
1.3 B (2)
1.4 C (2)
1.5 D (2)
1.6 C (2)
1.7 D (2)
[14]

QUESTION 2 MONKEY BUSINESS

2.1 2.1.1 The law of conservation of mechanical energy states that the total mechanical energy of a system remains constant provided no external force acts.

OR

The total mechanical system of an isolated system remains constant. (2)

2.1.2 E_k at B = E_p at A
$\frac{1}{2} mv^2 = mgh$
$(\frac{1}{2} \times 5,8 \times v^2) = (5,8 \times 10 \times 2,4)$
$v = 6,93\ m \cdot s^{-1}$
Accept $g = 9,8\ m \cdot s^{-2}$ as correct.
Answer : v = **$6,86\ m \cdot s^{-1}$** (4)

Alternative
$v = \sqrt{2gh}$
$= \sqrt{2 \times 10 \times 2,4}$
$v = 6,93\ m \cdot s^{-1}$ (2)

2.1.3 The total linear momentum of an isolated system remains constant. (2)
(Σ p initial = Σ p final)

2.1.4 p before collision = p after collision
$m_1v_{i1} + m_2v_{i2} = (m_1 + m_2)v_f$
$[(5,8 \times 6,93) + (1,2 \times 0)] = (5,8 + 1,2)v_f$
$v_f = 5,74\ m \cdot s^{-1}$ (4)

c/e

2.1.5 The collision at B is inelastic (kinetic energy is lost at B) therefore the gravitational potential energy at C will be less than at A therefore lower height ($E_p = mgh$).

The total mechanical energy of the system is equal to m_Agh (energy of adult monkey at A). The total mechanical energy of the system at B is equal to $(m_A + m_B)\ g\ \Delta y$.
Δy must therefore be less than h. At maximum (without loss of energy)

$$\Delta y = \frac{m_A}{m_A + m_B} . h$$

(Award only 1 mark – candidate has not noticed that the collision is inelastic.) (2)

2.2 2.2.1 A (1)

2.2.2 C (1)

2.2.3 constant deceleration (retardation) up OR constantly decreasing velocity up OR constant acceleration down (3)

2.2.4 Height (displacement) = area under the graph
= (½ × 2 × 20) + (2 × 4)
= 28 m
Alternatives

$\Delta y = \frac{(v_i + v_f).\Delta t}{2}$
$= \frac{(4 + 24).\ 2}{2}$
Height = 28 m

$\Delta y = v_i t + ½ a \Delta t^2$
$\Delta y = 4(2) + ½ (10).2^2$
Δy = 28 m

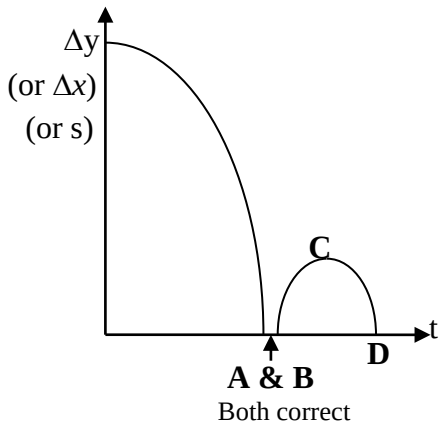
$v_f^{\ 2} = v_i^2 + 2a\Delta y$
$24^2 = 4^2 + 2(10)\ \Delta y$
Δy = 28 m (4)

2.2.5 $F_{net} = \frac{\Delta p}{\Delta t} = \frac{m(v_i - v_i)}{\Delta t}$ Conversion
$= \frac{0,15\ (-6 - 24)}{0,05}$
= - 90 N
F_{net} **= 90 N up**

OR

$a = \frac{\Delta v}{\Delta t}$ Both formulae
$= \frac{-6-24}{0,05}$
$= –600\ m{\cdot}s^{–2}$
$F_{net} = ma$
$= (0,15)(–600)$ conversion
$= –90\ N$
$F_{net} = 90\ N\ up$ (6)

2.2.6



(–1 if axes not labelled. Units not required.)
Both correct (6)

Full marks will also be awarded for graph rotated about *x*-axis.

[35]

QUESTION 3 GAME CAPTURE

3.1

3.1.1 $\Delta y = v_i\Delta t + \frac{1}{2} a\Delta t^2$

$125 = 0(t) + \frac{1}{2} (10).t^2$ (Accept 9,8 $m.s^{-2}$)

t = 5 s (Answer t = 5,05 s) (3)

3.1.2 $V_{dg} = 43 m\cdot s^{-1}$ west (**not** left) (2)

3.1.3 **Horizontal distance travelled by dart in 5 s**

$\Delta x = v_i t + \frac{1}{2} a\Delta t^2$ (a = o)

$= 43 \times 5$ $V_{dg} = 43 m\cdot s^{-1}$ west

= 215 m (to point P)

Distance travelled by sable in 5 s

$\Delta x = v_i t + \frac{1}{2} a\Delta t^2$ (a = o)

$= 15 \times 5$

= 75 m

But the sable was already 140 m ahead of the helicopter therefore sable will be (75 + 140) = 215 m from the position at which the dart was fired. Therefore the sable will arrive at point P at the same time as the dart (therefore will be hit.)

Alternative

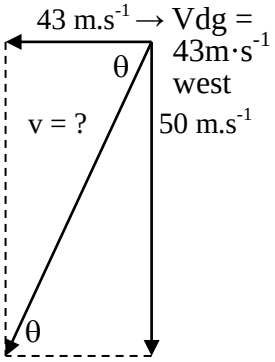
The dart is gaining on the sable by (43 – 15) = 28 m each second therefore in a time of 5 s the dart will have caught up to the sable by

$\Delta x = v_i t + \frac{1}{2} a\Delta t^2$ (a = o)

$= (28 \times 5) = 140$ m

This is the same as the original distance between them, therefore they will both arrive at P at the same time. (6)

3.1.4



Final vertical velocity

$v_f = v_i + a\Delta t$

$= 0 + 10.(5)$

$= 50 m\cdot s^{-1}$

Using 9,8 $m\cdot s^{-2}$ accept $v = 49 m\cdot s^{-1}$

Final velocity

$v^2 = 43^2 + 50^2$

$v = 65,95 m\cdot s^{-1}$

Using 9,8 $m\cdot s^{-2}$

$v = 65,19 m\cdot s^{-1}$

Alternative

$\left(mgh + \frac{1}{2} mv_2^{\ 2}\right) = \left(\frac{1}{2} mv_f^{\ 2}\right)$ method

$\left(10 \times 125\right) + \left(\frac{1}{2} \times 43^2\right) = \left(\frac{1}{2} \times v_f^{\ 2}\right)$

$1250 + 924,5 = \frac{1}{2} v_f^{\ 2}$

$v_f = 65,95\ m\cdot s^{-1}$ (5)

3.2 3.2.1 $v_f^2 = v_i^2 + 2a\Delta x$

$0,4^2 = 0^2 + 2a(0,5)$

$a = 0,16 \text{ m·s}^{-2}$

3.2.2 Work done by a force is defined as the product of the displacement and the component of the force acting in the direction of the displacement OR the amount of energy transferred by the force. (2)

3.3.3 $F_{app} = mg + ma$

$= (3\,000 \times 10) + (3\,000 \times 0,16)$

$= 30\,480$ N

Using 9,8 m·s^{-2}

Fapp = 29 880 N

$W = F\Delta y\cos\theta$ ($\theta = 0$)

$= 30\,480 \times 0,5$

W = 15 240 J Using 9,8 m·s^{-2}

W = 14 940 J

Alternative

$W = \Delta E_p + \Delta E_k$

$= (3000 \times 10 \times 0,5) + \frac{1}{2}(3000)\,0,4^2$

$= 15\,000 + 240$

$= 15\,240$ J

(6)

3.2.4 $P = F.v$

$= 30\,000 \times 0,4$

P = 12 000 W (4)

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QUESTION 4 WATER HOLE

4.1 Wind unreliable, (insufficient wind) no wind = no power . OR The windmill pumps were not working (old/damaged by animals) (ONE only) (1)

4.2 **Advantage:** Reliable – power available on demand
Disadvantage: Pollution, diesel is expensive (not free like wind & sun), diesel is a non-renewable fossil fuel, noisy (any ONE) (2)

4.3 **Advantage:** Uses renewable natural resource (sun), no pollution, no noise, sun is 'free' energy (any ONE)
Disadvantage: Unreliable, no sun = no power, initial set-up is expensive, fragile (large animals could damage solar panels), inefficient (poor conversion of solar energy to electricity), dust will block sunlight (any ONE) (2)

4.4 time taken (to pump 50 litres of water through a height of 80 m) (2)

4.5 **mass** (volume) of water and **height** (depth) (2)

4.6 They did not control the weather conditions/amount of sunlight received by solar panel
Pump C may not have been operating at full power since it was used on a cloudy morning therefore the solar panel had been exposed to less hours of sunlight than pumps A and B. If there were back-up batteries they may not have been fully charged. Therefore it is **not valid** to compare their results for pump C with pumps A and B. (3)

4.7 **Pump B**
The results were the most precise since they were the closest in value to one another
(smallest standard deviation) (3)

4.8 **Pump A**
The results were the least reliable since they showed the biggest variance in values when compared to one another. (Difference between best and worst time was 18,7 s.) The results indicate that the data is NOT reproducible. Repeating the experiment gives different results every time. (3)

4.9 **Pump B (A cannot be justified)**
Although the average time was slightly longer than pump A it gave more reliable results. (3)
[21]

QUESTION 5 WAVES

5.1 5.1.1 $f = \frac{v}{\lambda}$
$f = \frac{340}{68}$
f = 5 Hz therefore infrasonic (4)

5.1.2 **Infrasonic** as they have the **lowest frequency** and hence the **longest wavelength**. (The longer the wavelength the greater the degree of diffraction.) either (2)

5.2 5.2.1 **Supersonic** (1)

5.2.2 A sonic boom is the **sound heard when a shock wave passes**. (2)

5.2.3 (a) The Concorde is flying at a lower altitude
The Concorde is larger (has a greater surface area) (2)

(b) **Any TWO of the following are worth 2 marks each:**

The flight path of the military jets should not be over the game reserve.

The military jets should fly at high altitudes.

Reduce the speed to subsonic levels when flying near the game reserve.

Restrict the size of the aircraft permitted to be flown into and out of the air base. (4)

5.3 5.3.1 Seshni is more correct since the spectral line from the star has a **longer wavelength (lower frequency)**than usual which means that it is **shifted towards the red end of the spectrum**.

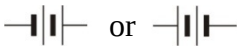
Possible explanations for the red-shift

- The light source (the star) is **moving away** from the Earth rather than towards the Earth. *(Mind Action Series Gd 12 p 7-3)*
- The star is not actually moving through space but space itself is expanding. *(Study & Master Gd 12 p 65).* The wavelengths 'stretch' as space expands. *(IEB p 1 2009)*
- The red shift is caused by the Doppler effect – the lower frequency shows the star is moving away from the Earth. *(Study and Master Grade 12, p 65)* (4)

5.4 5.4.1 (a) A
(b) C (2)

5.4.2 $\Delta E = -1,6 - (-10,4) = 8,8$ eV
$\Delta E = 8,8 \times 1,6 \times 10^{-19} = 1,408 \times 10^{-19}$ J (conversion)
$E = h.f$
$1,408 \times 10^{-19} = 6,6 \times 10^{-34} \times f$
$f = 2,13 \times 10^{15}$ Hz (5)
[26]

QUESTION 6 CAMPING FRIDGE

6.1 In series.  (1)

6.2 $P = V.I$
$P = 24 \times 6$
$P = 144$ W (3)

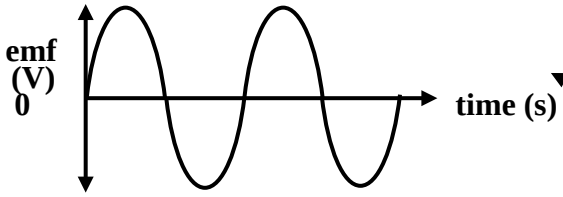
6.3 6.3.1 A diode is a device or (circuit) component that allows current to flow through it in one direction in an electric circuit. (2)

6.3.2 A rectifier changes a.c. to d.c. (2)

6.3.3 When W is positive current flows through **diode B** through the load **from Y to Z** and through **diode D** to X. (No current passes through diodes A and C which are in reverse bias.) (3)

6.3.4 Step-down (1)

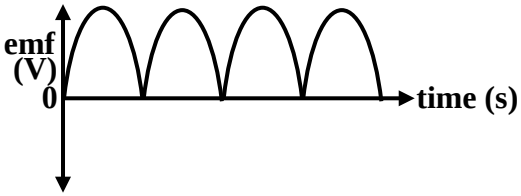
6.3.5 (a)



Ignore the scale or values shown on each axis.

(2)

(b)



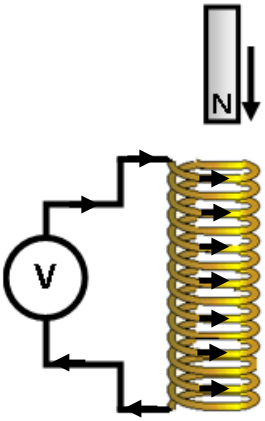
(2)

6.3.6 Capacitor (1)

[17]

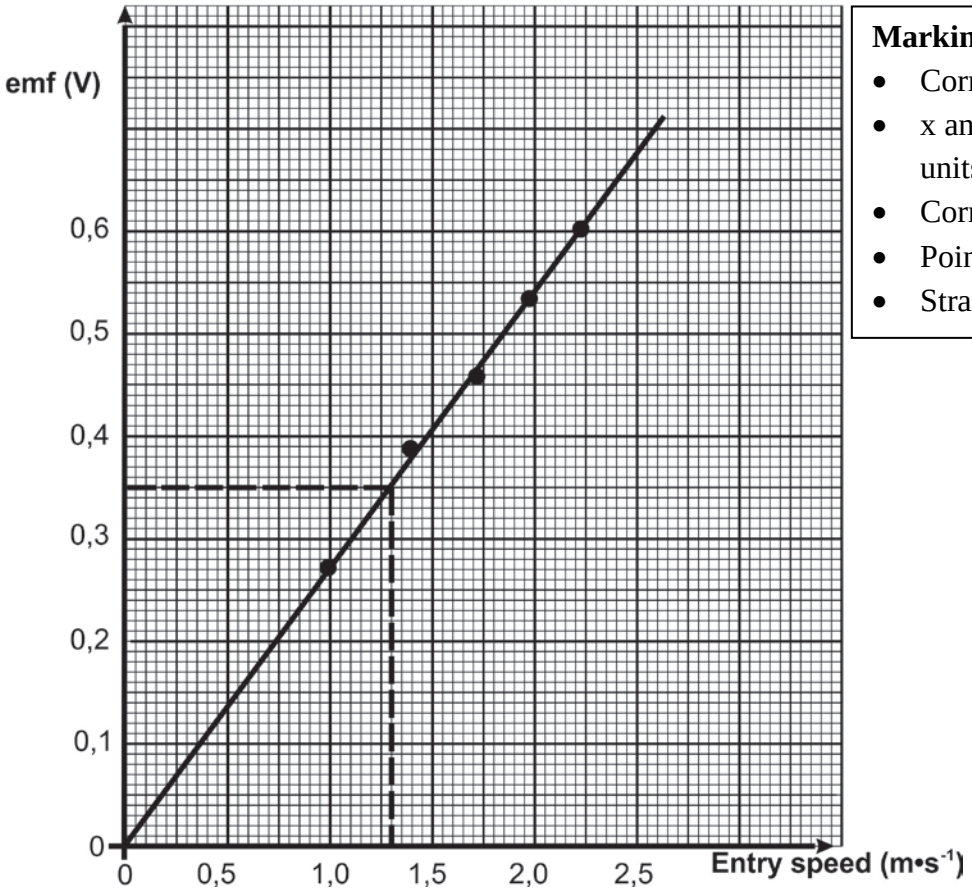
QUESTION 7 KINETIC TORCH

7.1



(2)

7.2 **Graph of maximum induced emf on entry against entry speed for the magnet falling through the solenoid**



Marking of graph
- Correct choice of axes
- x and y-axis labelled with units
- Correct scale both axes
- Points correct
- Straight line of best fit (7)

7.3 0,35 V (2)

7.4 The maximum induced emf is directly proportional to the speed of the magnet.
OR As the speed of the magnet increases the maximum induced emf increases. (2)

7.5 Increase the density of coils on the solenoid (more coils per unit length).
Use a stronger magnet.
Make the torch longer (so that falling magnet gains more speed).
Do not accept: Increase the length of the solenoid.
Any two for 2 marks each (4)

[17]

QUESTION 8 SOLAR FAN

8.1 When the light intensity increases the **number of photons increases**. Each photon transfers its energy to one electron which escapes therefore a **greater electrical current** is produced since there will be more charge flowing through the fan circuit per second (I = Q/t). (2)

8.2 8.2.1 The minimum frequency of light at which electrons will be emitted from a particular metal. (2)

8.2.2 $E = h \cdot f$
$E = 2{,}13 \times 1{,}6 \times 10^{-19}$
$= 3{,}41 \times 10^{-19}$J
$3{,}41 \times 10^{-19} = 6{,}6 \times 10^{-34} \times f$
$F = 5{,}17 \times 10^{14}$ Hz (5)

8.2.3 $E = W_f + \frac{1}{2} mv^2$
$E = 3{,}41 \times 10^{-19} + \frac{1}{2} \times 9{,}1 \times 10^{-31} \times (2{,}39 \times 10^5)^2$
$E = 3{,}67 \times 10^{-19}$J (4)

8.2.4 Increase (2)

8.3 8.3.1 Resistance is the ratio of the potential difference across a conductor to the current in the conductor. (2)

8.3.2 $P = \frac{V^2}{R}$ formula

$R = \frac{V^2}{P}$

$R_{100W} = \frac{240^2}{100}$ $R_{60W} = \frac{240^2}{60}$

= 576 Ω **= 960 Ω**

OR $I = \frac{P}{V}$

$I_{100W} = \frac{100}{240} = 0{,}417A$

$I_{60W} = \frac{60}{240} = 0{,}25$ A

$R = \frac{V}{I}$
$R_{100W} = 576\ \Omega$
$R_{60W} = 960\ \Omega$ (4)

8.3.3 **100 W** (1)

8.3.4 **60 W.** Both bulbs will receive the **same current** since they are connected in series, therefore the bulb with **more resistance** will be brighter as shown by the formula **$P = I^2R$** (P and R)
Note: If $V = I \cdot R$ is used then some reference to more energy per coulomb should also be stated. (4)
[26]

QUESTION 9 ELECTRIC LAND ROVER

9.1 In order to tell when the battery needs recharging. (or the battery is flat). (1)

9.2 Yes diesel is a fossil fuel burning it produces more CO_2 than making the motor and battery
OR
No. Making a motor and battery requires extraction of metals and compounds. Large industries use carbon fuels for this. (3)

9.3 Two marks for one clearly expressed pro; Two marks for one clearly expressed con; Two more marks for another pro or con. (6)

Pros

- No poisonous gas emissions (pollution) therefore animals and plants do not suffer (get ill/die) from breathing polluted air.
- No noise therefore animals not disturbed or frightened and visitors get closer to wild life.
- Reduced CO_2 emissions therefore reduction in global warming.
- Conserving non-renewable fuel (diesel)
- Possibility of recharging batteries using solar power (renewable energy source)

Cons

- Batteries take 6 hours to recharge therefore trips have to be carefully planned – you cannot rush off to a sighting that has been radioed in if your batteries are flat.
- They only last for 2,5 h which is less than a full tank of diesel would last. You would have to ensure that you are not far from the camp when your battery goes flat (i.e. less flexibility of time.)
- Batteries take up a lot of space and are heavy.
- Solar technology for recharging batteries has not been perfected yet. How are batteries charged after long periods of rain?

Overall opinion 1 meaningful point for 2 marks (some possible responses follow ...) (2)

I think that the conversion of Land Rovers from diesel to electric is a **valuable** project because ...

- The money, time and effort spent on the research and technology used in this project could be applied on a larger scale to other vehicles.
- It is better to make a small difference than no difference at all ...
- It is our responsibility to preserve our wild life and natural bush for future generations ...

OR I think that the conversion of Land Rovers from diesel to electric is a **meaningless** project because ...

- In the larger scheme of things a few electric vehicles will have no impact on the pollution, carbon footprint and consumption of fossil fuels caused by conventional vehicles.
- The money, time and effort spent on this project would have been better invested in ...

[12]

Total: 200 marks