# 2020 Sec 3 IP Physics EOY Exams Mark Scheme

## Paper 1:

| 1……..5 | 6…….10 | 11…..15 | 16…..20 | 21…..25 | 26…..30 |
|---|---|---|---|---|---|
| **CAABB** | **DAADD** | **CDCBA** | **CDDCB** | **BCBCA** | **ADCBD** |

3. density = m / V = $5.94 \times 10^{24}$ / ($1.08 \times 10^{12} \times \underline{\mathbf{10^9}}$) since 1 $km^3$ = $(1000\ m)^3$ = $10^9\ m^3$

9. $v^2 = u^2 + 2as$, find a where a is negative.
Same braking force means same deceleration. Find s.

10. During reaction time, distance already covered, d = speed x time = 100 km $h^{-1}$ x 0.50 s
$v^2 = u^2 + 2as$ where s = 100 m – d u = 100 km $h^{-1}$ = 27.78 m $s^{-1}$

11. u = 0, t = 1.0 s, s = 6.0 m ➔ $s = ut + \frac{1}{2}at^2$, find a.

13. Constant resultant force ➔ constant acceleration = constant gradient on v-t graph
3 graphs are for different objects.

15. Horizontally, no force acts between P and Q
Q: Fnet = ma ➔ 15 N = (10.0 kg) a
P: no horizontal force, a = 0 initially

18. Pushing X slightly causes it rotate and stay in its new position.
Pushing Y slightly can cause it to topple easily.

21. bubble of gas obeys Boyle's law: $p_1V_1 = p_2V_2$
At depth h: $p_1$ = Patm + hdg, $V_1$ = 15.0 $cm^3$
At surface: $p_2$ = Patm, $V_2$ = 22.5 $cm^3$

29. If mirror moves to the right from the stationary man at a speed u,
it is equivalent to the <u>man moving to the left</u> from the stationary mirror at speed u.
this will result in the man's <u>image moving to the right</u> from the mirror also at speed u.
Relative to moving man, his image is moving away from him at twice the speed or 2u.
2u = 3.0 m $s^{-1}$, so u = 1.5 m $s^{-1}$.

## Paper 2:

### Section A

1(a) Taking the average of the time for 10 oscillations will <u>reduce the random error</u> in the measurement of the period T.

(b) The first measurement could have a <u>miscount of the number of oscillations</u>.
Or Taking another measurement will <u>improve the reliability</u> of the measurements.

(c) The graph does not support the hypothesis. [No mark given for this alone!]
The hypothesis indicates that a <u>straight line graph</u> <u>passing through the origin</u> is expected.
The graph plotted is a <u>curve</u>,
and the graph <u>does not pass through (or very close to) the origin</u>.

2(a) $v = u + at$ ➔ $t = (v-u) / a = (0 – 44.1)\ m\ s^{-1} / (-10\ m\ s^{-2}) = 4.41\ s$

(b) Assume that there is negligible air resistance.

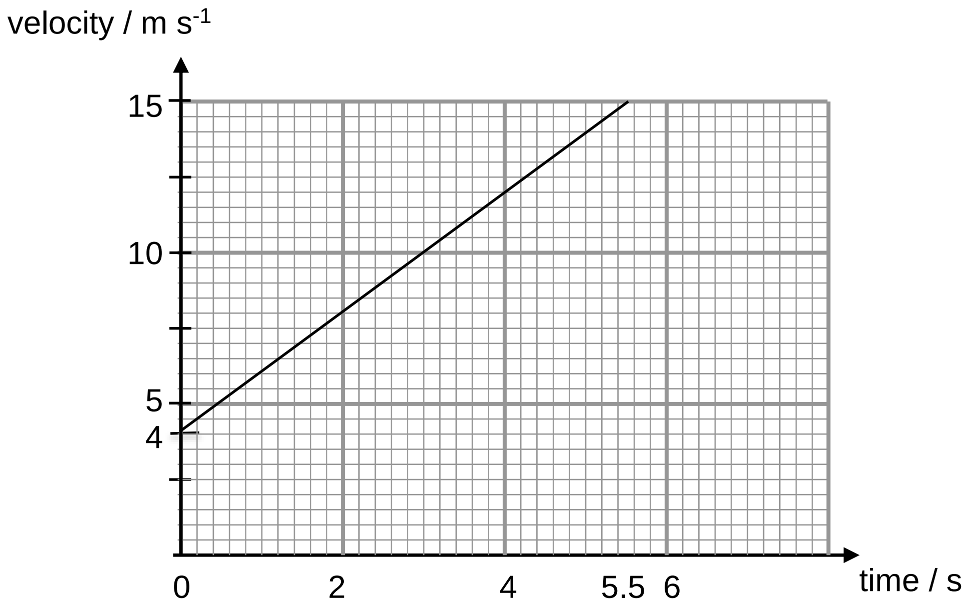
(c) $v^2 = u^2 + 2as$ ➔ $s = (v^2 – u^2) / (2a) = (0 - (44.1)^2) / 2(-10)$
$= 97.2\ m$

(d) Time taken to fall from maximum height = 6.0 – 4.41 s = 1.59 s
Distance travelled when falling down $s = ut + ½ at^2 = 0 + ½ (10\ m\ s^{-2})(1.59\ s)^2$
$= 12.64\ m$
Total distance travelled = 97.2 m + 12.64 m = 109.8 ≈ 110 m

3(a) $v = u + at$ ➔ $u = v – at = 10\ m\ s^{-1} – (2.0\ m\ s^{-2})(3.0\ s)$
$= 4.0\ m\ s^{-1}$

(b) $v = u + at = 10 + (2.0)(2.5) = 15\ m\ s^{-1}$

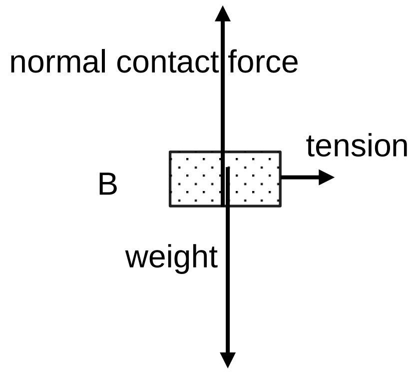
(c) Straight line from (0,4) to (5.5, 15) : *labelling of values <u>not</u> required!*



(d) $s = ut + ½at^2 = (4.0\text{ m s}^{-1})(5.5\text{ s}) + ½(2.0\text{ m s}^{-2})(5.5\text{ s})^2$
$= 52.25 \approx 52\text{ m}$

OR $s = v_{ave}t = ½(u+v)t = ½(4.0 + 15)(5.5) = 52\text{ m}$
OR use area under the graph

4(a)




**Comments:**
- Normal contact force and weight are equal in magnitude; hence both should be drawn to the same length.
- Forces must be labelled with words spelt in full.

(b) $m = 1.10$ kg, $M = 0.20$ kg
$F_{net} = m\,a$ ➔ $T = m\,a$ ①
$M\,g - T = M\,a$ ②
Combining ① + ②,
$M\,g = (m + M)a$ ➔ $a = [M/(m + M)]\,g = [0.20 / (0.20 + 1.10)]\,(10)$
$= 1.538 \approx 1.5\text{ m s}^{-2}$

(c) $T = m\,a = (1.10\text{ kg})(1.538\text{ m s}^{-2}) = 1.6918 \approx 1.7\text{ N}$

(d) $F_{net} = M\,a = (0.20)(1.538) = 0.3076 \approx 0.31\text{ N}$
*Allow for e.c.f. from (b)* OR $M\,g - T$

(e) When the string breaks, tension $T$ becomes zero
/ There is no net force on B Or By Newton's 1st law of motion,

B will continue moving to right with a constant velocity.

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(a) This is to ensure the weight of the lifting bar would not produce any moment to affect the balancing of the system.

(b) Taking moments about the pivot P
Clockwise moment = anticlockwise moment
$F \times 2.0\text{ m} = 500\text{ N} \times 0.5\text{ m}$
$F = 125\text{ N} = 130\text{ N}$ (2 s.f.)

(c) The (effort) force $F$ applied at Y will be much less than the weight to be lifted.

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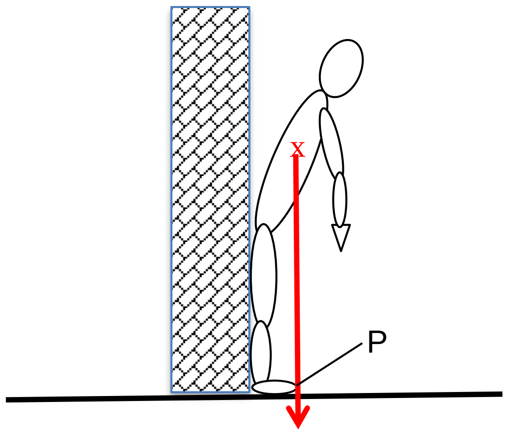
(a)




Note:

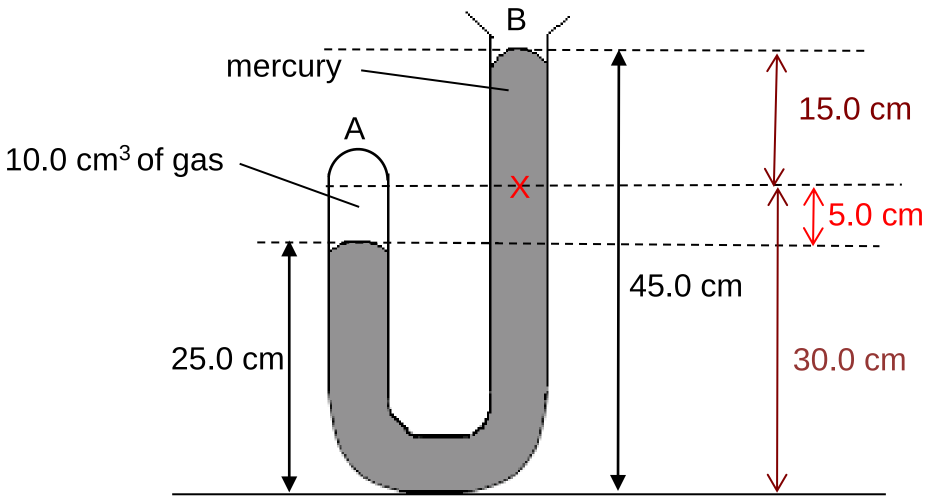
- The vertical line-of-action of weight must pass exactly at the end of the foot.

(b) The (vertical) line-of-action of weight falls outside the base of his feet when he tries to touch his toes. **OR** acts to the right of P (his toes)
The weight of the man produces a net clockwise moment about P (his toes) which rotates the man forward causing him to topple.

7(a)(i) Atmospheric pressure = 0.76 m x 13600 kg $m^{-3}$ x 10 m $s^{-2}$ = 1.03 x $10^5$ Pa

(ii) Excess pressure = 45.0 cm Hg – 25.0 cm Hg = 20.0 cm Hg
Gas pressure = 76.0 cm Hg + 20.0 cm Hg = 96.0 cm Hg

(b) Mark X in mercury and label a suitable distance on Fig. 7.1




7b) 'X' must be in mercury with correct suitable distance indicated on Fig. 7.1

(c)(i) 76.0 cm Hg

(c)(ii) $P_1V_1 = P_2V_2$
96.0 cm Hg x 10.0 $cm^3$ = 76.0 cm Hg x $V_2$
$V_2$ = 12.63 $cm^3$ ≈12.6 $cm^3$

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(a) Total energy = GPE at the start
$= 0.200 \text{ kg} \times 10 \text{ m s}^{-2} \times 6.0 \text{ m} = 12 \text{ J}$

GPE at D $= 0.200 \text{ kg} \times 10 \text{ m s}^{-2} \times 1.5 \text{ m} = 3.0 \text{ J}$
K.E. = Total energy – GPE at D = 12 – 3.0 = 9.0 J
**OR**
Increase in KE = Decrease in GPE
$= mg\Delta h$
$= 0.200 \text{ kg} \times 10 \text{ m s}^{-2} \times (6.0 - 1.5)\text{m} = 9.0 \text{ J}$

(b) K.E = 9 J = $\frac{1}{2} m v^2$
➔ $v = \sqrt{(9 \times 2)/0.200} = 9.487 \text{ ms}^{-1} \approx 9.5 \text{ ms}^{-1}$

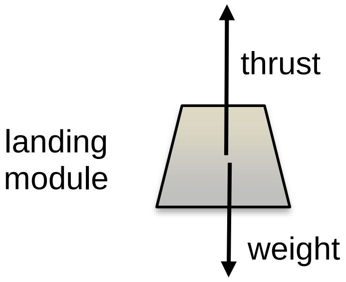
**Section B**

9(a)(i) This will shorten the time taken for the rover to reach Mars.

Accept: Less fuel is needed for the journey to Mars.

(a)(ii) average speed = d / t $= 55 \times 10^6 \text{ km} / (6 \times 30 \times 24) \text{ h}$
$= 12731 \approx 13\,000 \text{ km h}^{-1}$

(b)




(c)(i) $v = u + at$ ➔ $v = -9.0 \text{ m s}^{-1} + (3.0 \text{ m s}^{-1})(2.0 \text{ s})$
$= -3.0 \text{ m s}^{-1}$
Or velocity is <u>3.0 m s$^{-1}$ downwards</u>.

(c)(ii) From t = 4.5 to 5.0s, the module is falling freely, $a = -2.0 \text{ m s}^{-2}$
Acceleration due to free fall g is <u>2.0 m s$^{-2}$</u> on this planet

(c)(iii) $F - mg = ma$ ➔ $F = m(g + a) = 250 \text{ kg } (2 + 3) \text{ m s}^{-2}$
$= 1250 \text{ N}$

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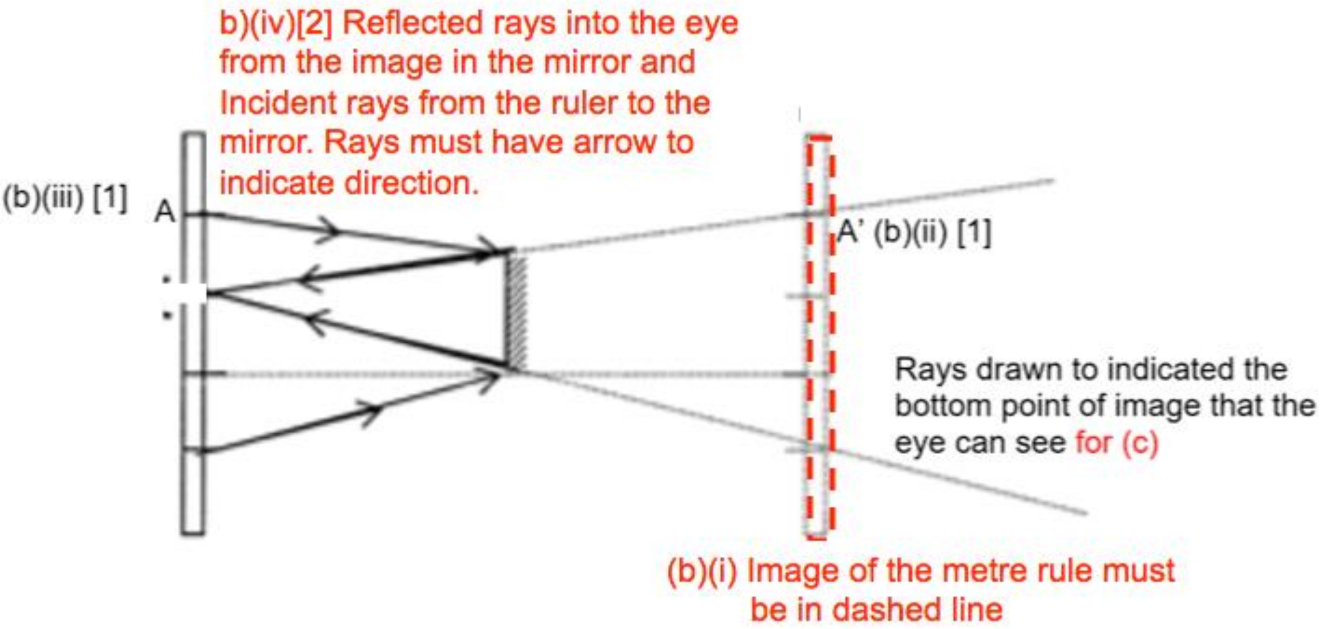
(a) Any 3: Image formed is [2]

- Virtual
- Upright
- Same size as object
- As far behind the mirror as the object is in front of the mirror
- Laterally inverted




(c) 80 cm – 20 cm = 60 cm
Rays drawn to indicated the bottom point of image that the eye can see

**OR** 5.0 m + 5.0 m = 10.0 m

$$\frac{x}{30\text{ cm}} = \frac{10.0\text{ m}}{5.0\text{ m}} \quad \rightarrow \quad x = 60\text{ cm}$$

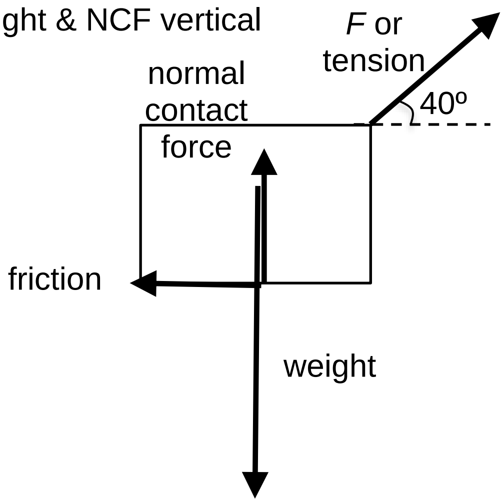
**OR** Length of image = 2 x size of mirror = 2 x 30.0 cm
= 60.0 cm or 0.600 m

(d) image distance from the reflective window = 5.000 m
horizontal distance from the man's eye to the image of the rule
= 5.000 m + 5.000 m = 10.000 m

**11 Either**

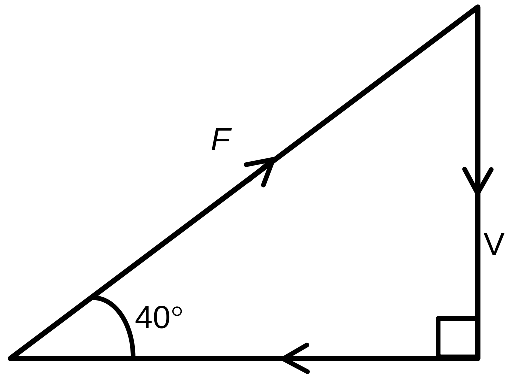
(a) The ice block has a large mass and hence a large inertia, so it is difficult to start it moving initially.
As the ice block begins to melt after a while, the layer of water between the block and ground reduces the friction, making it easier to pull the block.

(b) Note:
- names of forces fully spelled out
- accurate directions: $F$ drawn at 40º to horizontal, weight & NCF vertical
- length of NCF vector not longer than weight's
- weight to be drawn from c.g.
- NCF to be close to weight (1 mm apart)



(c) Note:

- a right angled Δ must be drawn
- right angled Δ with 1 vertex at 40°
- *F*, V and friction / 150 N labelled
- directions correctly marked




(d) $F \cos 40° - 150 \text{ N} = 0$ OR $F \cos 40° = 150 \text{ N}$

$F = 150 \text{ N} / \cos 40° = 195.8 \approx 196 \text{ N}$ (3 s.f.) OR 200 N (2 s.f.)

(e) Apply the force at a smaller angle to the horizontal.

$F = 150 / \cos 40°$, the smaller the angle (< 40°) , the smaller the value of *F*.

**11 OR**

(a) $F_R = 0$ N

(b)(i) work done = F x d = 120 N x 20 m
= 2400 J

b(ii) By law of conservation of energy, work done = gain in G.P.E. = 2400 J

b(iii) Height of ramp = 20 m / 4 = 5.0 m
G.P.E. = mgh
mg = weight = 2400 J / 5.0 m = 480 N

**OR**

Height of ramp = 20 m / 4 = 5.0 m
$T = W_x = W\sin\theta$
$W = T / \sin\theta = 120 / (5.0 \text{ m} / 20 \text{ m}) = 480$ N

(c)(i) Output Power = WD / time = 2400 J / 20 s
= 120 W

(c)(ii) useful output power =120 W, input power = 150 W
efficiency = (useful output power / input power ) x 100 % = 120 W / 150 W
= 80 %