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Exam Preparation and Free Resources

Name of the Student:_____

Max. Marks : 22 Marks   **Time : 22 Minutes**

Mark Schemes

Q1.

(a)   Any **one** from: ✔₁
- region in which a mass experiences force due to another mass
- (the field is conservative so) any change in potential energy only depends on the initial and final positions and not on path taken OWTTE
- the force is always attractive **OR** field lines point to the (centre of) mass **OR** the equipotential surfaces are spherical about the (centre of) mass
- gravitational force is a non-contact force

The field strength/force has an inverse-square variation (with distance). ✔₂

> ✔₁ *is a general point about gravitational fields*
>
> ✔₂ *is specific to a radial gravitational field*
>
> *The 'force is attractive' is insufficient*
>
> *When required the term "force" must be used rather than words like "effect&", "gravity" etc.*
>
> *When required the word 'mass' must be used rather than object or similar.terms*
>
> *Condone reference to "circular" for "spherical" in describing an equipotential surface*

2

(b)   The shaded area corresponds to:

the (minimum) energy needed/work done to launch the space probe to a height of 8×10^6 m

OR

the <u>change</u> in GPE of the probe when moved from Earth's surface to a height of 8×10^6 m ✔

1

(c)   Evaluates the gravitational field strength due to the Sun = 5.90×10^{-3} (N kg⁻¹)

OR shows substitution into a valid equation ✔₁

Evaluates $\dfrac{g_S}{g_E} \left(= \dfrac{5.90 \times 10^{-3}}{9.81} = \right)$ 6.0×10^{-4} or 0.060% ✔₂

✔₁ $g_s = \dfrac{GM_S}{r^2} = \dfrac{6.67 \times 10^{-11} \times 1.99 \times 10^{30}}{\left(1.50 \times 10^{11}\right)^2}$

✔₁ ALTERNATIVE

The Universal gravitational equation for both bodies may be used:

$$\frac{g_{Sun}}{g_{Earth}} = \frac{M_{Sun}}{M_{Earth}} \times \left(\frac{r_{Earth}}{r_{Sun}}\right)^2$$

✔$_2$ *Answer needed to at least 2 sf. If 3+ sf are seen, the answer must round to (6.01 or 6.02)×10^{-4}.*

2

(d)   The force from Earth because of its smaller mass, is less than the force from the Sun at a similar distance.

   OR

   The total work done in moving a long way from the Sun is much greater than that in moving a long way from the Earth because $m_E \ll m_S$.

   Condone reference to "edge of Solar System" as "a similar distance".

1

(e)   change in kinetic energy or kinetic energy per unit mass formulated ✔$_1$ allow 2 sf

   change in gravitational potential energy / potential formulated ✔$_2$

   evidence of intention to equate their ΔE_k and ΔE_p (even if not carried through; allow ecf) ✔$_3$

   mass of **X** = 6.3 × 10^{20} kg ✔$_4$

   ✔$_1$ $\frac{1}{2}m\left(v^2_B - v^2_A\right)$ **OR** *1.18 × 10^{10} (J)* **OR**

   $\frac{\Delta E_k}{m} = \frac{1}{2}\left(v^2_B - v^2_A\right)$ **OR** *m × 2.40 × 10^5 J*

   ✔$_2$ $\Delta E_p = GMm\left(\frac{1}{1.7\times10^5} - \frac{1}{6.0\times10^6}\right)$

   = GMm × 5.72 × 10^{-6}

   OR $\frac{\Delta E_p}{m} = GM\left(\frac{1}{1.7\times10^5} - \frac{1}{6.0\times10^6}\right)$

   Loss and gain may be replaced with change or Δ's for this mark.

   ✔$_3$ $\frac{1}{2}\left(v^2_B - v^2_A\right) = \frac{-GM}{r_A} - \frac{-GM}{r_B}$ *and*

   substitution of data into working equation.
   This can be seen anywhere in the solution.

4

[10]

Q2.

(a)   G has greater mass with evidence from diagram ✔$_1$

   Explanation based on gravitational field strength or gravitational potential ✔$_2$

   E.g.
   ALTERNATIVE A
   G has greater mass because null point is closer to H ✔$_1$
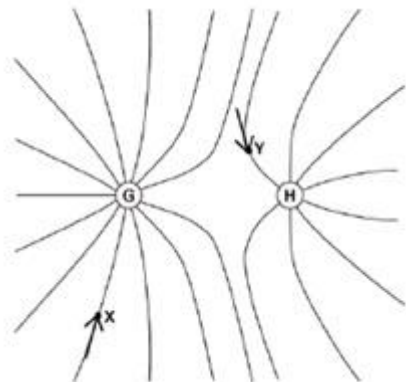   *G field equals that of H at a greater distance from null than H* ✔$_2$

2

(b) The lines given tangential arrows at X and Y that flow towards **G** and **H** respectively. ✔

Condone arrow heads only but if arrows are drawn in full they must not follow a curved line.

*Arrows are acceptable if drawn alongside X and Y but must not be further away than the **X** or **Y** label.*
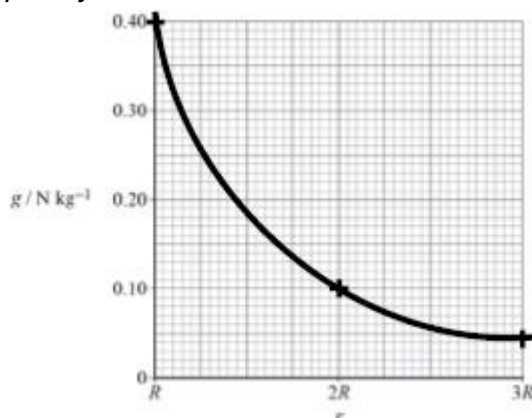
1

(c)

$$R = \left(\left\{\frac{GM}{g}\right\}^{1/2} = \left\{\frac{6.67 \times 10^{-11} \times 2.0 \times 10^{20}}{0.40}\right\}^{1/2}\right) = 1.8 \times 10^5 \text{ (m)} \checkmark$$

1

(d) Sketch must pass through coordinates $(R, 0.40)$, $(2R, 0.10)$ and $(3R, 0.044)$ ✔

Must be within one 1/2 small division of coordinates requested.

If plotted points differ a little from the line drawn then plotted points take priority.

1

(e) ALTERNATIVE A

(The area underneath) represents the energy transferred/work done (for an object) of 1 kg / unit mass ✔₁ₐ

Accept reverse direction $2R$ to R with appropriate direction of energy transfer/gravitational potential.

OR

(area is) energy transferred to/work done on the object per unit mass when it is moving from R to $2R$ ✔$_{1a}$✔$_{2a}$

> *In each alternative, the first answer is only awarded MP1. The second, fuller answer scores MP1 and MP2.*

ALTERNATIVE B
change in gravitational potential ✔$_{1b}$

OR

increase in gravitational potential when moving from R to $2R$ ✔$_{1b}$✔$_{2b}$

> *R may be given as 1.8×10^5*

2

(f) Use of $F = \dfrac{GMm}{r^2}$ to find the force between **P** and **H** ✔$_1$
($F_{(PH)} = 1.8 \times 10^{13}$ N)

✔$_1$ $F_{(PH)} = \dfrac{6.67\times10^{-11}\times3.0\times10^{25}\times2.0\times10^{20}}{\left(1.5\times10^{11}\right)^2}$

> ✔$_2$ *Mark is for the use of the equation allowing for ecf from candidate's force calculation.*

> ✔$_3$ *Correct answer only, no ecf this interim calculation may be subsumed in the next mark.*

(Calculation of the resultant force

Use of $F_{total} = \left(F_{(PH)}{}^2 + F_{(PG)}{}^2\right)^{1/2}$) ✔$_2$

$\left(F_{total} = \left[\left(1.8 \times 10^{13}\right)^2 + \left(6.4 \times 10^{12}\right)^2\right]^{1/2}\right)$

$F_{total} = 1.9 \times 10^{13}$ ✔$_3$

Use of $a = \dfrac{F}{m} = \dfrac{1.9\times10^{13}}{2.0\times10^{20}}$ = 9.4 to 9.5 × 10^{-8} (m s^{-2}) ✔$_4$

> ✔$_4$ *Allow ecf from F_{total}*

> *Condone the vector addition of the acceleration to obtain the answer*

> *acc^n due to G = 3.91 × 10^{-8} m s^{-2}*

> *acc^n due to H = 8.9 × 10^{-8} m s^{-2}*

4

(g) The resultant force is not (centripetal and continually) directed towards the centre of **H**.
OR
A circular orbit does not follow a gravitational equipotential (owtte) ✔

> *Condone lack of "resultant"*

> *The answer can focus on the conditions necessary for circular motion eg the need for a centripetal force.*

> *Or*

> *At different locations on a circular path the total gravitational potential*

energy is different which requires energy which is not provided.
NB stating that the force is not perpendicular to the motion does not count as a full explanation as the motion has not been established.

1

[12]