HSC Physics – Module 5: Advanced Mechanics – Motion in Gravitational Fields Short Answer Question Solutions 4

31. (a)

Criteria	Marks
Has axes correctly labelled, appropriate linear scales and plots the acceleration value for each data pair accurately AND draws a curved line of best fit.	2
Plots some points correctly and draws curved line of best fit.	1

(b)

Criteria	Marks
States that a new graph must be plotted of acceleration vs. 1/distance (or 1/a vs. distance) and that if the graph is linear, then distance and acceleration are inversely proportional.	2
States that acceleration should be plotted against 1/distance OR states that if a graph of acceleration vs. 1/distance2 is a straight line then acceleration is proportional to the inverse square of the distance.	1

32. (a)

Marking Criteria	Marks
• Correct answer calculated.	3
• Answer calculated with error in units or substitution	2
• Answer calculated with error made in units and one other error OR • Two steps of the calculation performed correctly	1

$T = 2 \times 60 \times 60 = 7200$ s

$\frac{r^3}{T^2} = \frac{GM}{4\pi^2}$

$r = \sqrt[3]{\frac{GM}{4\pi^2} \times T^2}$

$= \sqrt[3]{\frac{(6.67\times10^{-11})(6.0\times10^{24})}{4\pi^2} \times 7200^2}$

$= 8.1 \times 10^6$ m

(b)

Marking Criteria	Marks
• Answer calculated correctly	2
• Calculation made with an error	1

$F = \frac{Gm_1m_2}{d^2}$

$= 6.67 \times 10^{-11} \times (\frac{(4.00\times10^2)(6.0\times10^{24})}{8.07\times10^6})$

$= 2.46 \times 10^3$ N

Note: Consequent error from part (a) shown as CE

(c)

Marking Criteria	Marks
• All appropriate reasons given	2
• One appropriate reason given	1

The satellite's orbit is circular and so must have a centripetal force acting on it. This is provided by the gravitational force of Earth on the satellite.

33.

Marking Criteria	Marks
• Discusses eastward launch of rockets • Explains geostationary satellites • Explains low earth orbit satellites	5
• Discusses launch of rockets • Explains geostationary satellites OR • Explains low earth orbit satellites	4
• Describes launch of rockets AND • Describes geostationary satellites OR • Describes low earth orbit satellites	2-3
• Identifies eastward launch of rockets OR • Describes geostationary satellites OR • Describes low earth orbit satellites	1

Rockets are always launched to the east in order to receive a boost from the rotational speed of the Earth.
Satellites in low earth orbit are about 250 km-1000km high. This is the minimum height that satellites can exist to avoid significant atmospheric air friction. The space shuttle and spy satellites usually orbit in this region. These satellites orbit the earth once every 90 minutes. Geostationary satellites orbit the earth over the equator with a period of 23 hours 56 minutes & 4 secs (a sidereal day). This is the time that it takes for the earth to rotate once on its axis. A geostationary satellite will occupy the same position in space above the earth. Geostationary orbits are useful for communications and weather satellites.

34.

Criteria	Marks
Calculates the correct orbital period using either $\frac{R^3}{T^2} = contantor \frac{R^3}{T^2} = \frac{GM}{4\pi^2}$ Answer is 11.85 years, 4328 days or 3.74 x 108 seconds	3
Correctly substitutes all variables into either formula	2
Makes a correct substitution into either formula	1

35.

a) $$\boldsymbol{E_p = -\frac{Gm_1m_2}{r}}$$
$$= \frac{-(6.67\times10^{-11}\times6\times10^{24}\times1700)}{38\times10^6+6.38\times10^6}$$
$$= \boldsymbol{-1.53\times10^{10}J}$$

Criteria	Marks
Selects the correct equation, including the negative sign Uses the correct numerical values (adds altitude and radius) Converts kilometre to metre Gives correct numerical answer with the appropriate unit (J)	2
As above, but no conversion of kilometre to metre	1

Uses incorrected equation, (mgh) Correct unit used	0

b) $\boldsymbol{E_p = -\frac{Gm_1m_2}{r}}$

$= \frac{-(6.67\times10^{-11}\times6\times10^{24}\times1700)}{6.38\times10^{6}}$

$= \boldsymbol{-1.07\times10^{11}J}$

Criteria	Marks
Uses the correct equation, including the negative sign Converts kilometre to metre Gives correct numerical answer and unit (J)	2
As above, but no conversion of kilometre to metre	1
Uses incorrect equation (mgh) but with unit (J)	0

c)

The change in gravitational potential energy i.e. the difference between the values in (a) and (b), is the energy needed to life the satellite to the stated altitude.

Criteria	Marks
Identifies differences in GPEs means energy needed	1

36.

Marking Criteria	Marks
Explains that the doing of work (cause) produces changes in potential energy (effect) and writes down $F \times s = mgh = mg(r_2 - r_1) = G\frac{M_{planet}M_{other}}{r_2} - G\frac{M_{planet}M_{other}}{r_1}$	**2**
Writes down either the algebra OR the sentence	**1**

37.

Criteria	Marks
• Correct equation used • Values assigned to variables correctly • Correct answer with units	2
• ONE of the above	1

$$F = G\frac{m_{mass} \times m_{planet}}{r^2}$$

$$4.25 \times 10^2 = 6.67 \times 10^{-11}\frac{85.0 \times m_{planet}}{(8.00 \times 10^6)^2}$$

$$m_{planet} = \frac{4.25 \times 10^2 \times (8.00 \times 10^6)^2}{6.67 \times 10^{-11} \times 85}$$

$$= 4.80 \times 10^{24}\, kg\ (3\ sig.figs)$$

38. 3 marks

- Measurement is taken for multiple of swings (e.g. 10) then divided to give T

- Previous step is repeated (say 3 times) then averaged.
- A graph of T^2vL is made and gradient measured.
- Show how “g” is related to gradient.

Subtract 1 mark if procedure is poorly sequenced.
Subtract 1 mark for each missing part.

39.
(a) 3 marks

- The answer must state explicitly at least 2 similarities AND 1 difference (or vice versa). The differences and similarities stated must be correct.

2 marks

- Only 1 similarity and difference is given (or correct).

1 mark

- A correct similarity or difference is given.

(b) 2 marks

- Correct equation
- Correct answer with correct unit

40. (a)

Marking Criteria	Marks
• An appropriate method described	1

Sample answer:
e.g. measuring the time taken for 10 or 20 oscillations and dividing to find the period. OR stopwatch OR lightgates.

(b)

Marking Criteria	Marks
• An appropriate error is described that explains the graph	2
• An appropriate error is identifies	1