5 A research institute in Singapore sends nanosatellites into space. The mass of each nanosatellite is 100 kg. The nanosatellites are launched near Earth's equator to a low Earth orbit of 1.5×10^3 km above Earth.

The radius of Earth is 6.4×10^3 km and the mass of Earth is 6.0×10^{24} kg.

(a) A nanosatellite is launched in the same direction as Earth rotation, with a propulsion system that supplies 1.5×10^9 J of energy to the nanosatellite. Assume negligible air resistance and no loss in mass, calculate the kinetic energy of the nanosatellite when it just reaches the low Earth orbit.

kinetic energy = ... J [3]

(b) In Fig. 5.1, the dashed lines enclosing Earth represent gravitational equipotential lines. The equipotential lines for low Earth orbits with potentials ϕ_1 and ϕ_2 are shown.

On Fig. 5.1, draw the equipotential line for potential $\frac{\phi_2 - \phi_1}{2}$. [1]

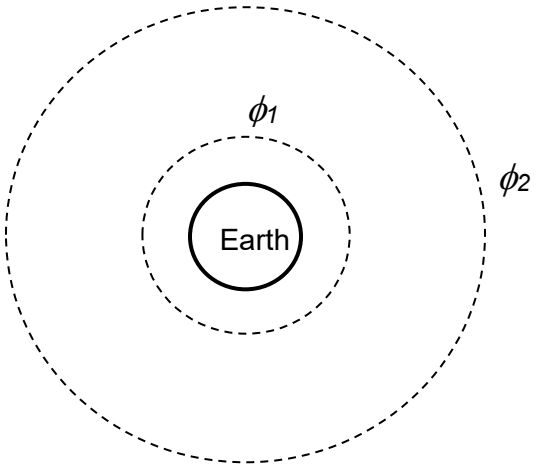

Fig. 5.1

(c) Fig. 5.2 shows the variation of the gravitational potential energy of a nanosatellite with distance from centre of Earth, *r*. At a certain distance *R* from the centre of the Earth, the total energy of the nanosatellite may be represented by a point on the line XY.
Five points, A, B, C, D, E have been marked on this line.

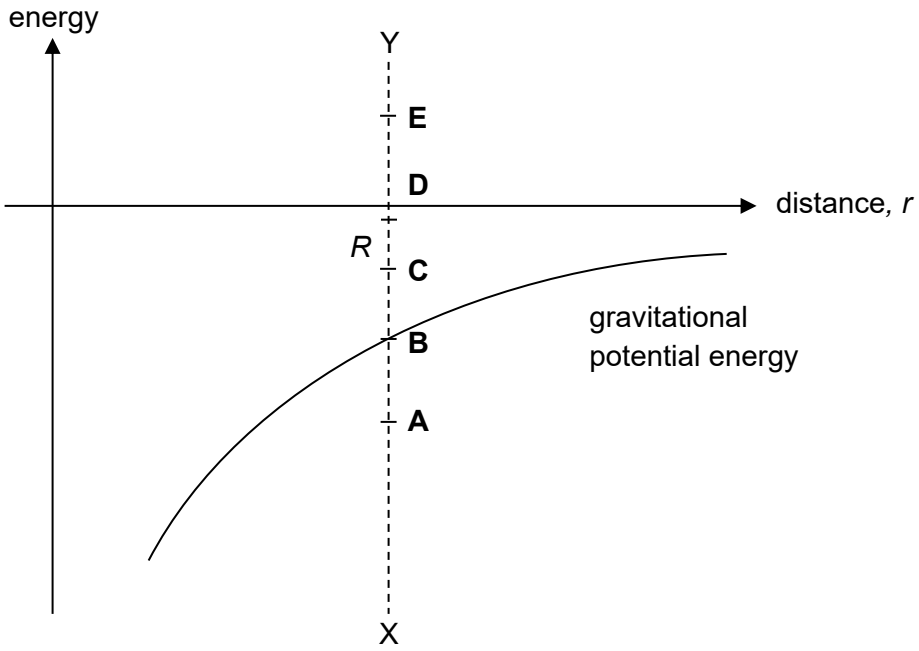

Fig. 5.2

(i) State what the gradient of the graph represents.

.....

..... [1]

(ii) Explain which point(s) can represent the total energy of the nanosatellite, if the nanosatellite is at distance *R* and is moving away from the Earth with sufficient energy to reach infinite distance.

.....

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.....

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..... [2]

[Total: 7]