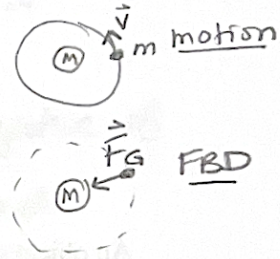
MCQ Set 3 – Solutions for Posting

1. B

Solution:

① Kinetic energy $= \frac{1}{2}mv^2$, so I need to know the speed of the satellite. It is moving in circular motion, so I know $a_r = \frac{v^2}{r}$ and $\Sigma F_r = ma_r$. I will apply N2L:



② $\Sigma F_r = ma_r$

$$\frac{GMm_s}{D^2} = m_s\frac{V^2}{D}$$

$$\sqrt{\frac{GM}{D}} = V$$

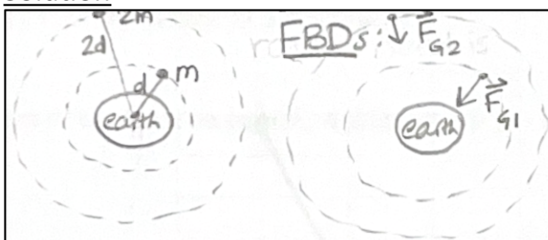
③ $K = \frac{1}{2}m_s v^2$

$$K = \frac{1}{2}m_s\left(\sqrt{\frac{GM}{D}}\right)^2$$

$$\boxed{K = \frac{GMm_s}{2D}}$$

2. C

Solution



I need the ratio $F_{G1} : F_{G2}$, so I need to find each:

$$F_{G1} = \frac{GM_e m}{d^2}$$

$$F_{G2} = \frac{GM_e(2m)}{(2d)^2} = \frac{GM_e m}{2d^2} = \frac{1}{2}\left(\frac{GM_e m}{d^2}\right)$$

So F_{G1} is double F_{G2}

3. B

Solution

(A) $E_1 = \frac{1}{2}E_2$

(B) $E_1 = E_2$

(C) $E_1 = 2E_2$

(D) $E_1 = 4E_2$

① The energy of a satellite is $U_G + K$. For large distances from earth, instead of $U_G = mgy$, I have to use $U_G = -\frac{GM_e m}{r}$. Kinetic is $K = \frac{1}{2}mv^2$, where the speed v is found using N2L applied to its circular motion. I did that in #1 and found that $v = \sqrt{\frac{GM_e}{r}}$.

② So now I can find an expression in general for a satellite of mass m_s and distance r from the center of M_e:

$$E = U_G + K = -\frac{GM_e m_s}{r} + \frac{1}{2}mv^2 = -\frac{GM_e m_s}{r} + \frac{1}{2}m\left(\sqrt{\frac{GM_e}{r}}\right)^2$$

$$= -\frac{GM_e m_s}{r} + \frac{GM_e m}{2r}$$

$$= -\frac{GM_e m_s}{2r}$$

③ Now figure E for each satellite:

Therefore,

$$E_1 = -\frac{GM_e(m)}{2(d)} = -\frac{GM_e m}{2d}$$

$$E_2 = -\frac{GM_e(2m)}{2(2d)} = -\frac{GM_e m}{2d}$$

EQUAL!

4. E

Solution

① $E = U + K$, and E is constant.

② Therefore, K will be greatest when U is smallest. This happens at $x = 3m$.

5. E

Solution

② $\text{Slope} = \frac{-4J}{.2m} = -20\frac{Nm}{m} = -20N$

x (m)

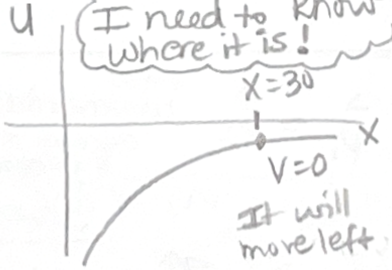
① $F = -\frac{dU}{dx}$, which is the negative of the slope of the U(x) graph.

③ Slope = −20N, so F = +20N.

6. D

Solution :This one is a bit tricky because the problem does not tell you the x position of the particle; it only tells you that it moved 10 m from where it was released. So you have to find its position x too.

② (I need to know where it is!)



It will move left.

So, when it has moved 10m, it is at $x = 20m$.

① $F = -\frac{dU}{dx}$

$= -\frac{d}{dx}\left(\frac{-400}{x}\right)$

$= 400\frac{d}{dx}(x^{-1})$

$= 400(-1)(x^{-2})$

$= -\frac{400}{x^2}$ (I need to know x)

③ Now I can use $F = \frac{-400}{x^2}$ → We want magnitude, so $F = \frac{400}{x^2}$

$x = 20\text{ m}$, so $F = \frac{400}{20^2} = 1\text{ N}$

7.B

Solution

- Kinetic energy increases because the energy stored in the spring becomes kinetic
- momentum is constant because there is no net impulse from external forces on the system.

8. C

Solution

$P_{ix} = P_{fx}$

$(2m)v = m(-v) + mv_f$

$2mv + mv = mv_f$

$3\cancel{m}v = \cancel{m}v_f$

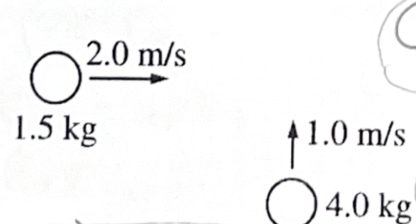
$3v = v_f$

$(2m) \rightarrow v$

$v \leftarrow (m)$ $\quad$ $(m) \rightarrow v_f$?

9. C

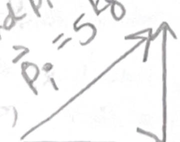
Solution



① $\vec{P}_i = \vec{P}_f$ total momentum vector before is equal to total momentum vector after

② $\vec{P}_i = \vec{P}_{ix} + \vec{P}_{iy}$ } I need $\vec{P}_i$

③ Find $\vec{P}_i$



$P_{iy} = (4.0\ kg)(1.0\ m/s) = 4\ kg\ m/s$

$P_{ix} = (1.5\ kg)(2.0\ m/s) = 3\ kg\ m/s$

④ Since $\vec{P}_i = 5\ kg\,m/s$, $\vec{P}_f = 5\ kg\frac{m}{s}$