作业务必自己抄一遍后再拍照上传，用文档图片上传后果自负。作业尽早提交，老师会尽快批改的，得分也会高一些。如果拖到期末补交普遍得分不高，附上源文档方便查看，如有数据看不清请对照源文档。

University Physics A(1) 2014

Worksheet #5

Name (名字): Student number (学号):

New words: Write the Chinese next to these words as you learn them.

rest energy	binding energy
kinetic energy	nuclear fusion
work	nuclear fission
potential energy	photon
gradient	neutrino

Problems
Show all working.

(1) [6.P.57] Jack and Jill are pulling a 3000 kg boat near a dock (码头). Initially the boat's position is $\langle 2, 0, 3 \rangle$ m and its speed is 1.3 m/s. As the boat moves to position $\langle 4, 0, 2 \rangle$ m, Jack exerts a force $\langle -400, 0, 200 \rangle$ N and Jill exerts a force $\langle 150, 0, 300 \rangle$ N.

(a) How much work does Jack do?

(b) How much work does Jill do?

(c) Without doing any calculations, say what is the angle between the (vector) force that Jill exerts and the (vector) velocity of the boat. Explain briefly how you know this.

(d) Assuming that we can neglect the work done by the water on the boat, what is the final speed of the boat?

(2) [6.P.95] In the rough approximation that the density (质量密度) of the Earth is uniform (均匀) throughout its interior, the gravitational field strength (force per unit mass) inside the Earth at a distance r from the center is gr/R, where R is the radius of the Earth. (In actual fact, the outer layers of rock have lower density than the inner core of molten iron.)

(a) Using this uniform-density approximation, calculate the amount of energy required to move a mass m from the center of the Earth to the surface. [HINT: the force is *not* constant!]

(b) Compare your answer from part (a) with the amount of energy required to move the mass from the surface of the Earth to a great distance away.

(3) [6.P.105] One of the nuclear fusion reactions (核聚变反应) that takes place inside a star such as our Sun is the production of helium-3 (^{3}He, with two protons and one neutron) and a gamma ray (high-energy photon, 光子) in a collision between a proton (^{1}H) and a deuteron (^{2}H, the nucleus of “heavy” hydrogen, 重氢, consisting of a proton and a neutron):

$$^{1}\mathrm{H} + {}^{2}\mathrm{H} \rightarrow {}^{3}\mathrm{He} + \gamma$$

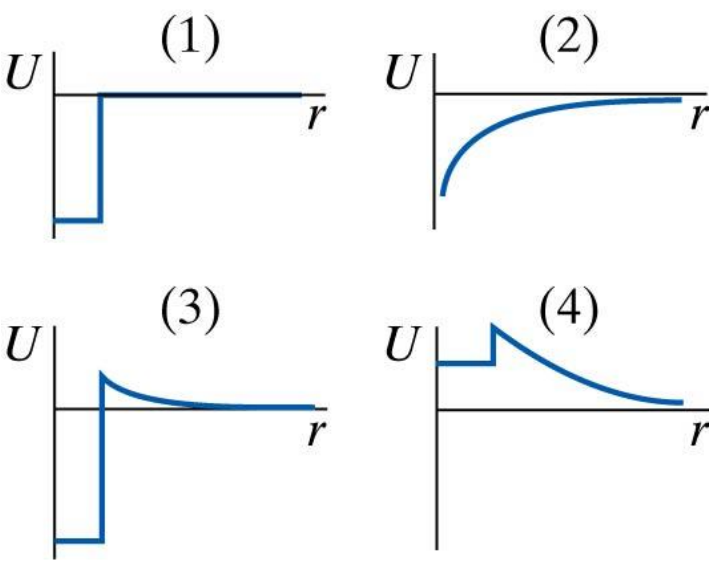
The rest mass of the proton is 1.0073 u (unified atomic mass unit, 1.7×10^{-27} kg), the rest mass of the deuteron is 2.0136 u, the rest mass of the helium-3 nucleus is 3.0155 u, and the gamma ray is massless.

(a) For this fusion reaction to take place, the proton and deuteron have to come close enough together to touch. The approximate radius (半径) of a proton or neutron is about 1×10^{-15} m. What is the approximate initial total kinetic energy of the proton and deuteron(when they are still far away from each other) required for the fusion reaction to proceed, in joules and electron volts ($1 \text{ eV} = 1.6 \times 10^{-19}$ joule)?

(b) Given the initial conditions found in part (a), what is the kinetic energy of the ^{3}He plus the energy of the gamma ray, in joules and in electron-volts?

(c) The net energy released is the kinetic energy of the ^{3}He plus the energy of the gamma ray found in part (b), minus the energy input that you calculated in part (a). What is the net energy release, in joules and in electron volts?

(d) Which of the following potential energy curves (1–4) is a reasonable representation of the interaction in this fusion reaction? Why?



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第五周作业

(1) (a) $W_{Jack} = \vec{F}_{Jack} \cdot \Delta\vec{r} = (-400, 0, 200)N \cdot [(4,0,2)m - (2,0,3)m]$
$= (-400, 0, 200)N \cdot (2, 0, -1)m$
$= -800 + 0 - 200 = -1000 J$

(b) $W_{Jill} = \vec{F}_{Jill} \cdot \Delta\vec{r} = (150, 0, 300)N \cdot (2, 0, -1)m = 300 + 0 - 300 = 0 J$

(c) 由(b)知：$W_{Jill} = 0 = |\vec{F}_{Jill}| \cdot |\Delta\vec{r}| \cos\theta$

又 $|\vec{F}_{Jill}| \neq 0$，$|\Delta\vec{r}| \neq 0$ 所以 $\cos\theta = 0$，则 $\theta = 90°$

(d) 由两个人和箱看成一个系统，由能量守恒定律有：

$\frac{1}{2}Mv_{末}^2 = \frac{1}{2}Mv_{初}^2 + W_{Jack} + W_{Jill}$ 又 $W_{Jill} = 0$

即 $v_{末} = \sqrt{v_{初}^2 + \frac{2}{M}W_{Jack}} = \sqrt{1.3^2 + \frac{2}{3000} \times (-1000)} \approx 1.0 m/s$

(2) 物体受到的引力：$|\vec{F}_{grav}| = m\frac{gr}{R}$

(a)

所需的能量：$W_1 = \int_{r=0}^{r=R} \vec{F}_{grav} \cdot d\vec{r} = \int_{r=0}^{r=R} \frac{mg}{R} r \cdot dr = \frac{mg}{R}\int_0^R r dr = \frac{mg}{R}\left[\frac{r^2}{2}\right]_0^R = \frac{1}{2}mgR$

(b) $W_2 = \Delta U_{grav} = U_f - U_i$ 因为 $U_f = 0$

则 $W_2 = -U_i = \frac{GMm}{R} = \frac{GMR}{R^2} \cdot m = mgR = 2W_1$

(3) (a) 由能量守恒定律有：

$U_i + K_i = U_f + K_f$ 因为 $U_i = 0$，$K_f = 0$ 所以 $K_i = U_f = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q_1 q_2}{r_f}$

把 $r_f = 1 \times 10^{-15} m$，$q_1 = q_2 = 1.6 \times 10^{-19} C$ 代入得 $K_i = 1.15 \times 10^{-13} J = 0.72 MeV$

(b) 当 ^3He 和 γ 射线产生时，由能量守恒定律有：

$E_{rest,proton} + E_{rest,deuteron} + K_i = E_{rest,He} + K_f$

$K_f = E_{rest,proton} + E_{rest,deuteron} + K_i - E_{rest,He}$
$= m_{proton}c^2 + m_{deuteron}c^2 + K_i - m_{He}c^2$
$= 1.50331 \times 10^{-10} J + 3.00513 \times 10^{-10} J + 1.15 \times 10^{-13} J - 4.50038 \times 10^{-10} J$
$= 8.06 \times 10^{-13} J + 1.15 \times 10^{-13} J = 9.21 \times 10^{-13} J \approx 5.9 MeV$

(c) $K_f - K_i = 9.21 \times 10^{-13} J - 1.15 \times 10^{-13} J = 8.06 \times 10^{-13} J \approx 5.2 MeV$

(d) 图3是正确的，因为核聚变前短距离相互作用，系统是有界的，因此 $U<0$，融合后相互作用力为排斥力，系统变无界，$U>0$，在 r 变大，U 衰减，所以在 $r \to \infty$ 时，$U \to 0$。