Física de Radiaciones 2
Segundo parcial
25/10/2022

<u>Prueba 2,5 horas de duración</u>

1. Se tienen iones de neón ($^{20}_{10}Ne^{+10}$, M_0= 18617,7 MeV/c^2) cuya energía cinética es 800 MeV. ¿Podrías estimar el tiempo en el cual son detenidos si inciden en tejido blando (músculo esquelético en este caso)? En caso afirmativo, halla dicho tiempo indicando qué suposiciones estás considerando para arribar al valor en cuestión.
2. Una fuente de ^{90}Y de 3,7 × 10^8 Bq se encuentra en un recipiente con blindaje plomo (Z = 82) que permite absorber partículas beta, cuyas energías máxima y promedio son 2,28 MeV y 0,94 MeV, respectivamente. Estime la tasa a la que es irradiada la energía por bremsstrahlung y la tasa de fluencia de fotones a 1 m de distancia de la fuente.
3. Considere una partícula de masa M con energía cinética T que colisiona con otra partícula de masa m en reposo.
    a. Calcule la máxima energía cinética T' que la partícula de masa m puede tener luego de la colisión, en función de m, M y T.
    b. Si m<<M y T<<Mc^2, obtenga la expresión aproximada de a en función de m y la velocidad incidente v de la partícula de masa M.
    c. Use la expresión apropiada, a o b, para calcular T' en los siguientes casos:
        i. Pion incidiendo sobre un electrón con T = 70 MeV y con T = 2 MeV.
        ii. Positrón incidiendo sobre un electrón con T = 0,15 MeV y con T = 150 MeV. Compare y explique los dos valores obtenidos.

Appendix B.2. Data Table for Compounds and Mixtures[a]

Material	Density (g/cm^3)[c]	Electron density (10^{23} e/g)	I (eV)[d]
A-150 plastic[b]	1.127	3.306	65.1
Adipose tissue (Fat, ICRP)[b]	0.92	3.363	63.2
Air[b]	1.205×10^{-3}	3.006	85.7
Bone, cortical (ICRP)[b]	1.85	3.139	106.4
Calcium fluoride, CaF_2	3.18	2.931	166
Carbon dioxide, CO_2	1.842×10^{-3}	3.010	85.0
Cesium iodide, CsI	4.51	2.503	553
Lithium fluoride, LiF	2.64	2.786	94.0
Lucite, $(C_5H_8O_2)_n$	1.19	3.248	74.0
Muscle, skeletal (ICRP)[b]	1.04	3.308	75.3
Mylar, $(C_{10}H_8O_4)_n$	1.40	3.134	78.7
Nylon, type 6 $(C_6H_{11}NO)_n$	1.14	3.299	63.9
Polycarbonate $(C_{16}H_{14}O_3)_n$	1.20	3.173	73.1
Polyethylene $(C_2H_4)_n$	0.94	3.435	57.4
Polyimide $(C_{22}H_{10}N_2O_5)$	1.42	3.087	79.6
Polypropylene $(C_3H_5)_n$	0.90	3.372	59.2
Polystyrene $(C_8H_8)_n$	1.06	3.238	68.7
Polyvinyl Chloride $(C_2H_3Cl)_n$	1.30	3.083	108.2
Pyrex (borosilicate glass)[b]	2.23	2.993	134
Silicon dioxide, SiO_2	2.32	3.007	139.2
Silver bromide, AgBr	6.47	2.629	487
Sodium iodide, NaI	3.67	2.571	452
Teflon, $(C_2F_4)_n$	2.20	2.890	99.1
TE gas (methane-based)[b]	1.064×10^{-3}	3.312	61.2
TE gas (propane-based)[b]	1.826×10^{-3}	3.314	59.5
TE liquid (no sucrose)[b]	1.070	3.313	74.2
Water, H_2O	0.9982	3.343	75.0

[a] Data from Berger and Seltzer (1983)

[b] See compositions in Appendix B.3

[c] Assuming $T = 20°C.$, $P = 1$ atm., and Charles' Law for gases applies.

[d] I is the mean excitation potential for stopping power, see Chapter 8.

PSTAR: Stopping Powers and Range Tables for Protons

MUSCLE, SKELETAL (ICRP)

Kinetic Energy MeV	Electron. Stp. Pow. MeV cm2/g	Nuclear Stp. Pow. MeV cm2/g	Total Stp. Pow. MeV cm2/g	CSDA Range g/cm2	Projected Range g/cm2	Detour Factor
9.500E-02	8.461E+02	1.641E+00	8.477E+02	1.484E-04	1.345E-04	0.9064
1.000E-01	8.412E+02	1.572E+00	8.428E+02	1.543E-04	1.404E-04	0.9096
1.250E-01	8.048E+02	1.304E+00	8.061E+02	1.846E-04	1.703E-04	0.9228
1.500E-01	7.589E+02	1.118E+00	7.600E+02	2.165E-04	2.020E-04	0.9329
1.750E-01	7.122E+02	9.807E-01	7.132E+02	2.505E-04	2.357E-04	0.9410
2.000E-01	6.685E+02	8.753E-01	6.694E+02	2.867E-04	2.717E-04	0.9477
2.250E-01	6.312E+02	7.914E-01	6.319E+02	3.251E-04	3.099E-04	0.9532
2.500E-01	5.990E+02	7.231E-01	5.998E+02	3.658E-04	3.503E-04	0.9578
2.750E-01	5.708E+02	6.657E-01	5.715E+02	4.085E-04	3.928E-04	0.9617
3.000E-01	5.456E+02	6.168E-01	5.462E+02	4.532E-04	4.374E-04	0.9650
3.500E-01	5.022E+02	5.386E-01	5.027E+02	5.488E-04	5.325E-04	0.9703
4.000E-01	4.658E+02	4.788E-01	4.663E+02	6.521E-04	6.354E-04	0.9744
4.500E-01	4.346E+02	4.315E-01	4.351E+02	7.632E-04	7.461E-04	0.9776
5.000E-01	4.075E+02	3.930E-01	4.079E+02	8.819E-04	8.644E-04	0.9801
5.500E-01	3.837E+02	3.611E-01	3.841E+02	1.008E-03	9.903E-04	0.9822
6.000E-01	3.628E+02	3.342E-01	3.632E+02	1.142E-03	1.124E-03	0.9839
6.500E-01	3.444E+02	3.112E-01	3.447E+02	1.284E-03	1.265E-03	0.9853
7.000E-01	3.279E+02	2.913E-01	3.282E+02	1.432E-03	1.413E-03	0.9865
7.500E-01	3.131E+02	2.739E-01	3.134E+02	1.588E-03	1.568E-03	0.9875
8.000E-01	2.998E+02	2.585E-01	3.000E+02	1.751E-03	1.731E-03	0.9884
8.500E-01	2.877E+02	2.447E-01	2.880E+02	1.922E-03	1.901E-03	0.9892
9.000E-01	2.767E+02	2.325E-01	2.770E+02	2.099E-03	2.077E-03	0.9898
9.500E-01	2.666E+02	2.214E-01	2.668E+02	2.283E-03	2.261E-03	0.9904
1.000E+00	2.573E+02	2.114E-01	2.575E+02	2.473E-03	2.451E-03	0.9910
1.250E+00	2.200E+02	1.727E-01	2.202E+02	3.527E-03	3.502E-03	0.9929
1.500E+00	1.932E+02	1.464E-01	1.934E+02	4.742E-03	4.713E-03	0.9941
1.750E+00	1.728E+02	1.272E-01	1.729E+02	6.111E-03	6.080E-03	0.9948
2.000E+00	1.567E+02	1.126E-01	1.568E+02	7.632E-03	7.597E-03	0.9954
2.250E+00	1.436E+02	1.011E-01	1.437E+02	9.299E-03	9.260E-03	0.9958
2.500E+00	1.328E+02	9.177E-02	1.329E+02	1.111E-02	1.107E-02	0.9962
2.750E+00	1.236E+02	8.407E-02	1.237E+02	1.306E-02	1.301E-02	0.9964
3.000E+00	1.158E+02	7.760E-02	1.159E+02	1.515E-02	1.510E-02	0.9966
3.500E+00	1.030E+02	6.732E-02	1.030E+02	1.974E-02	1.968E-02	0.9969
4.000E+00	9.295E+01	5.951E-02	9.301E+01	2.485E-02	2.478E-02	0.9971
4.500E+00	8.486E+01	5.336E-02	8.491E+01	3.048E-02	3.040E-02	0.9973
5.000E+00	7.819E+01	4.839E-02	7.824E+01	3.662E-02	3.653E-02	0.9974
5.500E+00	7.258E+01	4.429E-02	7.262E+01	4.326E-02	4.316E-02	0.9975
6.000E+00	6.779E+01	4.084E-02	6.783E+01	5.039E-02	5.027E-02	0.9976
6.500E+00	6.364E+01	3.791E-02	6.368E+01	5.800E-02	5.787E-02	0.9977
7.000E+00	6.001E+01	3.538E-02	6.005E+01	6.609E-02	6.595E-02	0.9978
7.500E+00	5.681E+01	3.317E-02	5.684E+01	7.466E-02	7.449E-02	0.9978
8.000E+00	5.397E+01	3.123E-02	5.400E+01	8.368E-02	8.350E-02	0.9979
8.500E+00	5.142E+01	2.951E-02	5.145E+01	9.317E-02	9.298E-02	0.9979
9.000E+00	4.912E+01	2.797E-02	4.915E+01	1.031E-01	1.029E-01	0.9979
9.500E+00	4.704E+01	2.659E-02	4.707E+01	1.135E-01	1.133E-01	0.9980
1.000E+01	4.514E+01	2.534E-02	4.517E+01	1.244E-01	1.241E-01	0.9980
1.250E+01	3.772E+01	2.055E-02	3.774E+01	1.852E-01	1.848E-01	0.9981
1.500E+01	3.254E+01	1.731E-02	3.256E+01	2.567E-01	2.563E-01	0.9982
1.750E+01	2.872E+01	1.497E-02	2.874E+01	3.387E-01	3.381E-01	0.9982
2.000E+01	2.577E+01	1.320E-02	2.578E+01	4.307E-01	4.299E-01	0.9983
2.500E+01	2.150E+01	1.069E-02	2.151E+01	6.440E-01	6.429E-01	0.9983
2.750E+01	1.990E+01	9.768E-03	1.991E+01	7.649E-01	7.636E-01	0.9984
3.000E+01	1.855E+01	8.996E-03	1.856E+01	8.950E-01	8.936E-01	0.9984
3.500E+01	1.638E+01	7.773E-03	1.638E+01	1.182E+00	1.181E+00	0.9984
4.000E+01	1.471E+01	6.849E-03	1.472E+01	1.505E+00	1.503E+00	0.9985
4.500E+01	1.339E+01	6.124E-03	1.339E+01	1.862E+00	1.859E+00	0.9985
5.000E+01	1.231E+01	5.541E-03	1.231E+01	2.251E+00	2.248E+00	0.9985
5.500E+01	1.141E+01	5.062E-03	1.142E+01	2.674E+00	2.670E+00	0.9985
6.000E+01	1.066E+01	4.660E-03	1.066E+01	3.127E+00	3.122E+00	0.9986
6.500E+01	1.001E+01	4.319E-03	1.002E+01	3.611E+00	3.606E+00	0.9986
7.000E+01	9.452E+00	4.025E-03	9.456E+00	4.125E+00	4.119E+00	0.9986
7.500E+01	8.961E+00	3.769E-03	8.965E+00	4.668E+00	4.662E+00	0.9986
8.000E+01	8.529E+00	3.545E-03	8.532E+00	5.240E+00	5.233E+00	0.9986
8.500E+01	8.144E+00	3.346E-03	8.147E+00	5.840E+00	5.832E+00	0.9986
9.000E+01	7.799E+00	3.169E-03	7.802E+00	6.468E+00	6.459E+00	0.9986
9.500E+01	7.489E+00	3.010E-03	7.492E+00	7.122E+00	7.112E+00	0.9987
1.000E+02	7.208E+00	2.867E-03	7.210E+00	7.802E+00	7.792E+00	0.9987
1.250E+02	6.123E+00	2.318E-03	6.125E+00	1.158E+01	1.157E+01	0.9987
1.500E+02	5.384E+00	1.949E-03	5.386E+00	1.595E+01	1.593E+01	0.9987
1.750E+02	4.849E+00	1.683E-03	4.850E+00	2.085E+01	2.082E+01	0.9988
2.000E+02	4.442E+00	1.482E-03	4.444E+00	2.624E+01	2.621E+01	0.9988

ENERGY	STOPPING POWER COLLISION	RADIATIVE	TOTAL	CSDA RANGE	RADIATION YIELD	DENS.EFF. CORR. (DELTA)
MeV	MeV cm²/g	MeV cm²/g	MeV cm²/g	g/cm²		
0.0100	8.428E+00	2.045E-02	8.448E+00	8.253E-04	1.191E-03	4.841E-04
0.0125	7.357E+00	2.251E-02	7.379E+00	1.143E-03	1.500E-03	6.147E-04
0.0150	6.561E+00	2.421E-02	6.585E+00	1.502E-03	1.810E-03	7.491E-04
0.0175	5.946E+00	2.566E-02	5.971E+00	1.901E-03	2.121E-03	8.872E-04
0.0200	5.453E+00	2.693E-02	5.480E+00	2.339E-03	2.432E-03	1.029E-03
0.0250	4.714E+00	2.908E-02	4.743E+00	3.323E-03	3.051E-03	1.324E-03
0.0300	4.182E+00	3.086E-02	4.213E+00	4.444E-03	3.664E-03	1.633E-03
0.0350	3.779E+00	3.240E-02	3.812E+00	5.694E-03	4.271E-03	1.956E-03
0.0400	3.463E+00	3.376E-02	3.497E+00	7.066E-03	4.872E-03	2.294E-03
0.0450	3.208E+00	3.500E-02	3.243E+00	8.552E-03	5.467E-03	2.646E-03
0.0500	2.997E+00	3.613E-02	3.034E+00	1.015E-02	6.055E-03	3.011E-03
0.0550	2.821E+00	3.718E-02	2.858E+00	1.185E-02	6.638E-03	3.390E-03
0.0600	2.670E+00	3.817E-02	2.708E+00	1.365E-02	7.214E-03	3.783E-03
0.0700	2.426E+00	3.998E-02	2.466E+00	1.752E-02	8.349E-03	4.608E-03
0.0800	2.237E+00	4.162E-02	2.279E+00	2.175E-02	9.461E-03	5.485E-03
0.0900	2.087E+00	4.313E-02	2.130E+00	2.629E-02	1.055E-02	6.413E-03
0.1000	1.964E+00	4.454E-02	2.008E+00	3.113E-02	1.162E-02	7.392E-03
0.1250	1.738E+00	4.772E-02	1.785E+00	4.438E-02	1.419E-02	1.005E-02
0.1500	1.583E+00	5.054E-02	1.633E+00	5.905E-02	1.664E-02	1.300E-02
0.1750	1.471E+00	5.312E-02	1.524E+00	7.492E-02	1.896E-02	1.623E-02
0.2000	1.387E+00	5.555E-02	1.442E+00	9.180E-02	2.118E-02	1.971E-02
0.2500	1.269E+00	6.015E-02	1.329E+00	1.280E-01	2.533E-02	2.736E-02
0.3000	1.193E+00	6.460E-02	1.257E+00	1.668E-01	2.917E-02	3.579E-02
0.3500	1.140E+00	6.900E-02	1.209E+00	2.074E-01	3.276E-02	4.484E-02
0.4000	1.102E+00	7.340E-02	1.175E+00	2.494E-01	3.614E-02	5.437E-02
0.4500	1.074E+00	7.781E-02	1.152E+00	2.924E-01	3.935E-02	6.426E-02
0.5000	1.053E+00	8.228E-02	1.135E+00	3.361E-01	4.241E-02	7.442E-02
0.5500	1.037E+00	8.677E-02	1.124E+00	3.804E-01	4.536E-02	8.479E-02
0.6000	1.026E+00	9.132E-02	1.117E+00	4.250E-01	4.820E-02	9.529E-02
0.7000	1.009E+00	1.005E-01	1.110E+00	5.149E-01	5.363E-02	1.166E-01
0.8000	1.000E+00	1.098E-01	1.110E+00	6.050E-01	5.877E-02	1.380E-01
0.9000	9.957E-01	1.193E-01	1.115E+00	6.949E-01	6.369E-02	1.595E-01
1.0000	9.939E-01	1.290E-01	1.123E+00	7.843E-01	6.842E-02	1.809E-01
1.2500	9.966E-01	1.537E-01	1.150E+00	1.004E+00	7.960E-02	2.337E-01
1.5000	1.004E+00	1.792E-01	1.183E+00	1.219E+00	9.009E-02	2.854E-01
1.7500	1.014E+00	2.053E-01	1.219E+00	1.427E+00	1.001E-01	3.360E-01
2.0000	1.024E+00	2.319E-01	1.256E+00	1.629E+00	1.096E-01	3.855E-01
2.5000	1.044E+00	2.866E-01	1.331E+00	2.016E+00	1.277E-01	4.817E-01
3.0000	1.063E+00	3.427E-01	1.406E+00	2.381E+00	1.447E-01	5.743E-01
3.5000	1.080E+00	3.999E-01	1.480E+00	2.728E+00	1.608E-01	6.631E-01
4.0000	1.095E+00	4.582E-01	1.553E+00	3.057E+00	1.761E-01	7.479E-01
4.5000	1.108E+00	5.174E-01	1.626E+00	3.372E+00	1.906E-01	8.289E-01
5.0000	1.120E+00	5.773E-01	1.698E+00	3.673E+00	2.045E-01	9.061E-01
5.5000	1.132E+00	6.379E-01	1.769E+00	3.962E+00	2.177E-01	9.798E-01
6.0000	1.142E+00	6.991E-01	1.841E+00	4.239E+00	2.304E-01	1.050E+00
7.0000	1.160E+00	8.233E-01	1.983E+00	4.762E+00	2.543E-01	1.182E+00
8.0000	1.175E+00	9.495E-01	2.125E+00	5.249E+00	2.765E-01	1.304E+00
9.0000	1.189E+00	1.077E+00	2.266E+00	5.705E+00	2.970E-01	1.417E+00
10.0000	1.201E+00	1.206E+00	2.407E+00	6.133E+00	3.162E-01	1.523E+00
12.5000	1.226E+00	1.535E+00	2.761E+00	7.102E+00	3.589E-01	1.759E+00
15.0000	1.246E+00	1.870E+00	3.116E+00	7.954E+00	3.955E-01	1.964E+00
17.5000	1.262E+00	2.210E+00	3.472E+00	8.713E+00	4.274E-01	2.147E+00
20.0000	1.277E+00	2.554E+00	3.830E+00	9.399E+00	4.555E-01	2.310E+00
25.0000	1.299E+00	3.252E+00	4.551E+00	1.059E+01	5.028E-01	2.596E+00
30.0000	1.318E+00	3.961E+00	5.278E+00	1.161E+01	5.412E-01	2.841E+00
35.0000	1.332E+00	4.678E+00	6.011E+00	1.250E+01	5.731E-01	3.055E+00
40.0000	1.345E+00	5.402E+00	6.747E+00	1.329E+01	6.002E-01	3.247E+00
45.0000	1.356E+00	6.132E+00	7.488E+00	1.399E+01	6.235E-01	3.420E+00
50.0000	1.365E+00	6.865E+00	8.231E+00	1.463E+01	6.439E-01	3.579E+00
55.0000	1.374E+00	7.603E+00	8.977E+00	1.521E+01	6.618E-01	3.725E+00
60.0000	1.381E+00	8.345E+00	9.726E+00	1.574E+01	6.777E-01	3.861E+00
70.0000	1.395E+00	9.836E+00	1.123E+01	1.670E+01	7.048E-01	4.107E+00
80.0000	1.406E+00	1.134E+01	1.274E+01	1.753E+01	7.270E-01	4.326E+00
90.0000	1.415E+00	1.284E+01	1.426E+01	1.828E+01	7.457E-01	4.521E+00