

Asteroid Mining

Grade 12 – Planetary Science

Using the JPL Small Object Browser

Website: <u>http://ssd.jpl.nasa.gov/sbdb_query.cgi</u> The following is a summary of the **tutorial**.

Part 1: Specify Search Constraints

Select the type of small-body you would like to investigate. There are 3 types of characteristics offered:

a) Limit by object type/group:

Object Group: Do you want Near Earth Objects (NEO's), Potentially Hazardous Asteroids (PHA's) or All Objects? Object Kind: check either asteroids or comets or All Objects Numbered State: check all objects

b) Limit to select orbit classes:

If no classes are selected, the search is unrestricted. You may select any of the orbit class titles (in blue) for more information, research them online, and you may want to locate the orbit classes using this image.

c) Limit by object characteristics:

This part is tricky. There are many combinations of physical parameters and orbital parameters. You may wish to consult outside resources such as https://en.wikipedia.org/wiki/Asteroid_mining and https://www.planetaryresources.com/2015/08/how-we-choose-our-asteroid-targets/

You need to use operators such as:

<	less than the specified single "value"
<=	less than or equal to the specified single "value"
>	greater than the specified single "value"
>=	greater than or equal to the specified single "value"
range	within the range specified (e.g. "4 9.2", "0.8-1.3", "-40:-2")
!=	not equal to the specified "value"
REGEXP	matching the specified "regular expression"
defined	the parameter is defined (has a non-NULL value)

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not defined the parameter is *not* defined (NULL value) And when you have defined the parameter, select "Add \rightarrow "

For **physical parameters**, you may want to consider features such as: Diameter: the approximate diameter of the asteroid in km Example: "diameter" "<=" "1" (means diameter of less than or equal to 1 km)

Rotation Period: the time it takes for the body to rotate about its own axis in hours Example: "rot_per(h)""<=""24" (means rotation period of less than 24 h)

Spectral Type (SMASS-II) and/or Spectral Type (Tholen): <u>Asteroid Spectral Types</u> Example: "spec. type (SMASS-11)" "=""X" (means spectral type X)

For **orbital parameters**, you may want to consider such features as: Perihelion (q): the closest distance to the sun (measured in AU) Example: "q""=""1" (means the object passes 1AU from the sun – this is the same as the distance from the sun to the Earth)

Inclination (i): the angle between the plane of the asteroid's orbit and the Earth's orbit (measured in degrees)

Example: "i" "<=" "1" (means that the object's orbit is tilted less than 1 degree with respect to the Earth's orbit)

Earth minimum orbit intersection distance (MOID (AU)): the distance between the closest points in the orbit of the object and the orbit of the Earth Example: "MOID (AU)" "=" "1" (means that the closest point between the object and the Earth is 1 AU (the distance between the Earth and the sun))

Period (in days or years): how long it takes for the object to orbit the sun once Example: "Period (d)" "=" "365" (means the period is 365 days (the same as the period of the Earth)

Part 2: Output Fields

I suggest using the pre-defined field sets – either "asteroid – basic" or "comet – basic" And then "Append Selected"

Part 3: Format Options

Leave on the default (HTML) and select "Generate Table" Be patient. You may need to try different combinations. Start with the most basic criteria and then add one constraint at a time to refine your list.

For example: A simple query for Near Earth Objects that are asteroids with a C-Type spectrum:



Led to only 9 objects:

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Constraints: aste	roids and	NEOs an	d spec. type	= C (SMAS	SII)								
object fullname	а	е	i	node	peri	a	Q	period	data-arc span	condition code	# obs. used (total)	# obs. used (del.)	# obs. used (dop.)
?	(AU) ?	?	(deg) ?	(deg) ?	(deg) 🤋	(AU) 🤋	(AU) ?	(years) 🤋	(d) ?	?	?	?	?
14402 (1991 DB)	1.715	0.4021	11.42	158.26	51.30	1.026	2.41	2.25	6739	0	425		
64 Davidharvey (1999 RH27)	2.849	0.5892	4.54	335.60	104.82	1.170	4.53	4.81	7564	0	937		
65706 (1992 NA)	2.397	0.5571	9.71	349.37	8.19	1.062	3.73	3.71	8646	0	298		
05774 (4000 LIT40)	1.404	0.3291	13.59	64.71	50.01	0.942	1.87	1.66	9192	0	593	4	4
85774 (1998 0118)		0.4654	17.38	296.29	37.00	0.613	1.68	1.23	6273	0	267		
136793 (1997 AQ18)	1.147	0.4034			100.05	0.026	1.56	1.39	5281	0	201		
136793 (1997 AQ18) 162567 (2000 RW37)	1.147 1.248	0.2501	13.75	333.34	133.25	0.550	1.50		0201		201		
136793 (1998 0118) 162567 (2000 RW37) 175706 (1996 FG3)	1.147 1.248 1.054	0.2501 0.3499	13.75 1.99	333.34 299.72	133.25 24.01	0.685	1.42	1.08	6560	0	1620	4	
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85/74 (1995 0116) 136793 (1997 AQ18) 162567 (2000 RW37) 175706 (1996 FG3) 370061 (2000 YO29) 446804 (1999 VN6)	1.147 1.248 1.054 1.815 1.733	0.2501 0.3499 0.6938 0.3703	13.75 1.99 54.60 19.48	333.34 299.72 262.66 58.09	133.25 24.01 309.32 43.60	0.685 0.556 1.091	1.42 3.07 2.38	1.08 2.45 2.28	6560 4632 5982	0	1620 56 269	4	

You can then click on the name of any one of these objects for more details.

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1	show orbit diagram]							*
ſ	Orbital Elements at E Reference: 141 Element Value a 1.7154691 q 1.025658 i 1.141802 node 159.25814 node 159.25814 period 2457397.1070 period 22.057800 n 4.3866168 Q 2.4052724 show covariance maths 2.0010120	Epoch 24: 44 (helio e 50486474 307695592 50486474 00651533 46492538 98502354 09675081 36889569 17826724 57071783) 779305943 2.255 76791533 94321415 4 1 1 1 1 1 1 1 1 1 1 1 1 1	57400.5 centric Uncerta 2 3 4 1 3 5 3 5 4 1 1 2 3 4 1 1 2 3 4 1 1 2 3 4 1 1 3 5 3 5 3 5 3 5 3 5 5 5 5 5 5 5 5 5 5 5 5 5	(2016- eclipti ainty (1 .1349e .6461e .3811e 8.03e-(.3229e .1488e .104e- .6192e .1812e 3.234e- .3137e .308e-	Jan-13. c J2000 1-sigma +08 +09 +08 06 +05 +05 +05 +05 +05 +05 +05 +06 09 +10 09	b) TDB # obs. used (trial) 425 # data-arc span 6739 days (first obs. used (1991-02-13) au last obs. used 2009-07-27 au last obs. used 2009-07-27 deg continon code 0 fir RMS .48 deg continon code 0 fir RMS .48 deg data source ORB producer Otto Matic solution date 2014-Juno5 4 degd au yr yr yr yr yr b) TDB au last obs. used (1000 - 2,59374) au continon code 0 Additional Information y jup = 4.064	aers 18.45 yr) 6 20.54:57	
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	Parameter	Symbol	Value	Units	Sigma	Reference	Notes	
	absolute magnitude	н	18.6	mag	n/a	MPO219630		
	diameter	diameter	0.6	km	n/a	Delbo et al. (2003). Icarus, v. 166, pp. 116-130		
	rotation period	rot_per	2.2656	h	n/a	LCDB (Rev. 2016-February); Warner et al., 200	Result based on less than full coverage, so that the period may be wrong by 30 percent or so. Published Reference List: [Pravec, P.; Wolf, M.; Sarounova, L. (2000) http://www.asu.cas.cz/~ppravec/neo.htm] [Koehn, B.W.; Bowell, E.L.G.; Skiff, B.A.; Sanborn, J.J.; et al. (2014) Minor Planet Bul. 41, 286-300.]	
	geometric albedo	albedo	0.14		n/a	Delbo et al. (2003). Icarus, v. 166, pp. 116-130		
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Another interesting factor is to look at the close approach data to see the next time the object will pass close to Earth. Select "show close approach data".

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14402 (1991 DB)	Discovered 1	991-Feb-18 by He	elin, E. F. at Palon	har							
Reference: 20000	418/Numbers.arc	La	st Updated: 2004-04	-19							
hide close-approa	ch data j										
Close-Approach L	Jatasorted by Date/1	Time (TDB)									
Date/Time (TDB)	(days_HH:MM) Bod	Nominal Distance (au)	Minimum Distance (au)	Maximum Distance (au)	V-relative (km/s)	V-infinity (km/s)	JD (TDB)	Time Uncertainty (minutes)	Semi-major axis (km)	Semi-minor axis (km)	range-LO
1937-Jun-16 02:23	< 00:01 Eart	h 0.463355966635277	0.463352646583069	0.463359286694413	17.6446161862073	17.6442902824316	2428700.599649185	0.0569114196357356	182.095134449464	18.444280098196	-22.6144
1946-Jun-07 14:51	< 00:01 Eart	h 0.358273443295964	0.358270675183417	0.358276211418952	13.9360036326192	13.9354699687462	2431979.119086348	0.0706063928003682	157.312755487426	16.6197237798248	-27.7425
1955-May-27 05:33	< 00:01 Eart	h 0.277620257645983	0.277618238394896	0.277622276910095	10.5108847478593	10.5099716006522	2435254.731462907	0.0998570750114007	119.543125820108	13.523958796267	-32.3100
964-Apr-29 00:37	< 00:01 Eart	h 0.216158009303871	0.216156458881043	0.216159559726563	7.57989295768263	7.57826656823809	2438514.525730700	0.171309638966626	66.8951546485557	7.06646330708253	-21.885
973-Mar-30 22:17	< 00:01 Eart	h 0.155884676013022	0.155883516610281	0.155885835418781	7.01666124326854	7.0142248138769	2441772.428806975	0.0890725234356942	31.9344641212424	4.92334139135907	25.0236
982-Mar-24 07:07	< 00:01 Eart	h 0.120419310490097	0.120418792610908	0.120419828371866	7.67878466102116	7.67590258626598	2445052.796308222	0.0417624275680204	19.9574250795672	6.3026535021424	51.2176
1991-Mar-21 16:37	< 00:01 Eart	h 0.107070535013012	0.107070289015182	0.107070781011397	8.23848167725599	8.23546050949212	2448337.192655893	0.025831142994746	10.4438562745796	6.48483616438499	56.4699
2000-Mar-18 21:49	< 00:01 Eart	h 0.101829830329531	0.101829628743459	0.101830031915553	8.79770310868947	8.79472842040609	2451622.409037049	0.0209687658339651	7.31242249175905	3.94229152666776	0.87758
009-Mar-15 22:31	< 00:01 Eart	h 0.113002606757871	0.11300238594362	0.113002827572066	9.88748992622978	9.88510491612675	2454906.438065540	0.018760034767901	8.68100031827626	5.50302451934395	-7.8325
018-Mar-11 17:42	< 00:01 Eart	h 0.163064208720997	0.163063853369928	0.163064564072087	11.7684682706506	11.7670797274689	2458189.237246063	0.0186204548383697	16.3629991760579	7.70426348789756	-26.976
027-Mar-06 18:35	< 00:01 Eart	h 0.25742861682278	0.257428053605636	0.257429180040009	14.4871504581094	14.4864359893031	2461471.274205507	0.0187910790268552	26.8135202991052	8.15430425837648	-18.646
036-Feb-29 12:30	< 00:01 Eart	h 0.369494003703912	0.369493271361318	0.369494736046494	17.6462063031064	17.6457976463925	2464753.020831252	0.0179985903744357	35.8786809833568	8.40243257256283	-13.393
083-Jun-17 10:25	< 00:01 Eart	h 0.432345871218661	0.432344651194118	0.432347091243631	16.7989933826792	16.7986265208527	2482027.933861794	0.0265756417273468	62.2628233651136	15.8312483378386	-15.762
1092-Jun-06 19:21	< 00:01 Eart	h 0.326792735081302	0.326791613857066	0.32679385630613	12.8600760193811	12.8594419932848	2485305.305937035	0.0346306466700311	57.7962780688232	13.7353731252338	-22.192
101-May-24 21:15	< 00:01 Eart	h 0.250812108634333	0.250811199855543	0.250813017414066	9.29588091585659	9.29473803751219	2488578.385703294	0.0528857150362146	46.273337326053	10.4006896061302	-26.939
110-Apr-17 10:45	< 00:01 Eart	h 0.197332466498482	0.197331629907025	0.197333303088756	6.90477000129792	6.90281419379414	2491827.948118840	0.0712864505677082	27.0232042881545	4.18673609302473	-4.8915
2119-Apr-01 09:38	< 00:01 Eart	h 0.153586666268849	0.153586029772384	0.153587302765535	6.98740449701878	6.98492124877436	2498098.901281112	0.0469073628467461	18.4636194744794	4.54628414585358	23.4838
128-Mar-25 07:01	< 00:01 Eart	h 0.121523160260174	0.121522755545566	0.121523564975607	7.7060702733521	7.70322449851898	2498379.792396837	0.0361185697388053	16.1295868238481	6.32381324238132	52.3136
137-Mar-22 08:08	< 00:01 Eart	h 0.107699427456392	0.107699180021286	0.107699674892783	8.40789855814644	8.40495557677748	2501663.838922627	0.0361170223631819	20.1257131654487	7.24329828500973	81.9700
146-Mar-19 17:22	< 00:01 Eart	h 0.107793183207412	0.107792878786035	0.10779348763591	9.27111002901676	9.2684434664091	2504948.223583674	0.0456219538649113	38.374087729618	7.49003093901066	-71.3493
155-Mar-16 23:09	< 00:01 Eart	h 0.129206847463485	0.129205552802506	0.129208142143759	10.4684097862755	10.4664396621283	2508232.464818692	0.0646651737295045	79.3206416940292	7.68557554876155	-47.684
164-Mar-11 07:38	< 00:01 Eart	h 0.19869945874238	0.198696634908713	0.198702282581856	12.778151256451	12.777101797436	2511514.818344277	0.0729283849267691	136.694174388026	8.04793316509224	-25.477
173-Mar-05 23:01	< 00:01 Eart	h 0.303758644227447	0.303754873924716	0.303762414529765	15.838718150683	15.8381643273189	2514796.458776473	0.0692145359744154	182.397612030789	8.46645529856546	-14.532
173-Jul-03 06:23	00:01 Eart	h 0.488195566996	0.488194516546708	0.488196617450861	4.54708225627304	4.54588180911975	2514915.765835186	1.13979205891563	47.3734810148095	13.6975309477151	-71.6490
2182-Feb-27 20:27	< 00:01 Eart	h 0.438314182759207	0.438309946412293	0.438318419105955	19.6191499358325	19.6188400868486	2518077.352352447	0.0603175363680134	209.821745356749	8.97829558408752	-8.93051
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For example 14402 will next pass within 0.163 AU of Earth in 2018: